THE EFFECT OF PAVEMENT TYPE AND EDGE LINES ON LATERAL PLACEMENT

DEC., 1957

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by

P. Weckesser

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

FINAL REPORT

THE EFFECT OF PAVEMENT TYPE AND EDGE LINES ON LATERAL PLACEMENT

TO: K. B. Woods, Director
Joint Highway Research Project

December 18, 1957

FROM: H. L. Michael, Assistant Director

File: 8-4-18
Project C36-17R

Attached is a report entitled, "The Effect of Pavement Type and Edge Lines on Lateral Placement," by P. M. Weckesser, graduate assistant on our staff. This report was performed under the direction of Harold L. Michael and was used by Mr. Weckesser as his thesis in partial fulfillment of the requirements for the M.S.C.E. Degree.

The first part of the study is a report of a restudy of the lateral placement on the U.S. 31 Test Road as requested by our Board. Although the results given by this restudy are similar to the first study, a number of the significant findings of the first study are not substantiated by the findings of the second study.

The second part of the study concerns the effect on lateral placement of edge lines on tangents. The study reports no significant differences in lateral placement for a road with or without edge lines on tangents.

That portion of the study dealing with the U.S. 31 Test Road has been reproduced for submission to the Test Road Committee.

The report is submitted for the record.

Respectfully submitted,

Harold L Michael

Harold L. Michael, Assistant Director
Joint Highway Research Project

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FINAL REPORT

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by

P. M. Weckesser
Graduate Assistant

Joint Highway Research Project
File: 8-4-18
Project C36-17R

Purdue University
Lafayette, Indiana

December 18, 1957

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ABSTRACT

Weckesser, Paul Maurice. MSCE., Purdue University, January, 1958. THE EFFECT OF PAVEMENT TYPE AND EDGE LINES ON LATERAL PLACEMENT. Major Professor: Harold L. Michael.

The purposes of this study were to investigate the lateral placement of passenger cars and semi-trailer trucks on a four-lane divided highway with similar sections of bituminous concrete and portland cement concrete pavement and determine if there were any effects of the lateral placement of these vehicles by the type of pavement; and, also, to investigate the lateral placement of passenger cars on 20', 22', and 24' bituminous pavements and semi-trailer trucks on a 24' bituminous pavement before and after the placement of edge lines and determine if the presence of edge lines had any effect on the lateral placement of these vehicles.

The lateral positions of the vehicles were determined by means of a segmented electrical detector consisting of a common bottom strip of spring steel 12' long and twelve individual topcontacts--each 11" long and separated from the bottom strip by rubber spacers. The twelve individual top contacts were connected by means of separate electrical leads to twelve pens on an Esterline-Angus 20-Pen Graphic Recorder. The action of the vehicle's wheels crossing the detector forced the contacts together; thus, closing an electrical circuit, which caused the appropriate pen for the one-foot zone in which

the vehicle crossed the detector to be actuated. These actuations were recorded by means of these pens on a chart moving at constant speed.

This study showed that the mean lateral placements of passenger cars and semi-trailer trucks were not significantly different between the two types of pavement. The mean lateral placement of passenger cars was not significantly different between day and night on either pavement typr; however, this mean for semi-trailer trucks was significantly farther from the edge at night than during the day on both types of pavement. The variance of the lateral position of passenger cars was found to be significantly greater on bituminous concrete than on portland cement concrete. No significant differences in the variances of semi-trailer trucks were found between the two types of pavement; nor were the day variances significantly different from the night variances on either type of pavement for either passenger cars or semi-trailer trucks. The percents of passenger cars in the other three feet of pavement and more than five feet from the pavement edge were not significantly different between pavement types nor between periods of observation. The percents of semi-trailer trucks in the outer two feet of pavement and more than four feet from the pavement edge were not significantly different between the types of pavement nor between the periods of observation.

The edge line portion of the study showed that the presence of edge lines on the pavement has no significant effect on the mean lateral placements or the variance in the lateral positions of passenger cars or semi-trailer trucks. It was found, however, that the mean lateral placement of passenger cars is approximately 4" greater on the 22' pavement and approximately 10" greater on the 24' pavement than on the 20' pavement during both day and night, before and after edge lining. Also it was found that the variability of passenger cars and semi-trailer trucks was decreased slightly in all cases after edge lining both at night and during the day. The percents of passenger cars traveling in the outer two feet of pavement and more than five feet from the pavement edge was not significantly different on any of the pavement widths after edge lining, nor significantly different between day and night observations.

THE EFFECT OF PAVEMENT TYPE AND EDGE LINES ON LATERAL PLACEMENT

INTRODUCTION

The path which a vehicle follows in traversing a given section of highway is an important factor in highway design, highway capacity computations, and accident analysis. In order to produce economic highway designs and to make effective the various traffic control devices employed to provide for safe and efficient vehicle movement, the lateral position of a vehicle on a highway and the factors which influence this, if any, must be known.

Among the many factors which are known to have influence on lateral placement, some of the more important ones are pavement width, shoulder type and width, location of roadside vertical obstructions, median strips, barrier curbs, and pavement markings. Depending upon the roadway conditions, the effects of these on the vehicle path are in some cases advantageous and provide for efficient movement while in others they produce effects causing vehicles to travel in an unsafe and inefficient manner. Because of the many variables involved and the differences in driver reactions to existing roadway conditions, it is impossible to make assumptions as to exactly the safest and most economical conditions. Consequently, scientific studies of all variables involved must be performed in order to supply highway designers and traffic engineers with the data necessary to enable them to establish adequate design and traffic control device standards.

With the advent of the Nation's largest highway construction program, the highway designer is constantly striving to produce designs which will economically provide maximum safety for the large volumes of traffic traveling the highways today. A minor but important consideration in each roadway design is the type of pavement which will be used, portland cement concrete or bituminous concrete. The properties and effects of each of these pavement types in relation to vehicle movement and safety must be carefully considered. Consequently, driver reaction and resultant vehicle path for different pavement conditions must be known by the highway designer before maximum safety can be incorporated into his designs.

Although the new highway program is replacing many miles of obsolete highways with high type, limited access facilities containing every safety feature known to the designer, there are already in existence many miles of two-lane highways which now carry and will continue to carry large volumes of traffic. These highways, too, must be made as safe as possible and the traffic engineer must determine methods of accomplishing this. The newest tool of the traffic engineer which is being used at an ever increasing rate for safety purposes is the pavement edge line. To use this tool economically and obtain maximum efficiency from its use, driver reaction and resultant vehicle path caused by the pavement edge line, are two of the most important factors in determining its value.

This study is concerned entirely with the effect of pavement type and edge lines on the lateral placement of vehicles. The various factors have been investigated and the recognized variables taken into consideration. It is, therefore, hoped that the findings and recommendations of this study will provide highway designers and traffic engineers with a more complete knowledge of the effects of pavement type and pavement edge lines on the lateral placement of vehicles, and, consequently, help contribute to their task of providing for the safe and efficient movement of vehicles on the highway.

PREVIOUS INVESTIGATIONS

The two factors investigated in this study, namely, pavement type and pavement edge lines have been the object of previous research in recent years.

D. Rosenfield, in 1955, while a graduate student at Purdue University conducted a similar study on the effect of pavement type on the lateral placement of vehicles (9). The major finding of his study was that the mean lateral placement of passenger cars and semi-trailer trucks was farther from the right edge of the pavement on portland cement concrete than on bituminous concrete. It was on the basis of this and other findings in his study that further research was deemed valuable in order to determine the reproducibility of his results and conclusions.

Research in the field of pavement edge lines to date has been limited to a few studies performed by the Bureau of Public Roads and some state highway departments. The first published study was performed under the direction of I. L. Thomas of the Louisiana Department of Highways in cooperation with the Bureau (13). His investigation, however, was limited to the effects of pavement edge lines on the speeds and lateral placements of vehicles on 24' surfaces only. A. Taragin of the Bureau conducted a study investigating the effects of pavement edge lines when used on two-lane bituminous highways with full width paved shoulders (11). In addition to these studies, the Subcommittee

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Numbers in parentheses refer to the Bibliography on Marking of the National Joint Committee on Uniform Traffic Control Devices and two technical committees of the Highway Research Board have begun investigations into the field of pavement edge lines, however, there are no published results as yet from either of these sources.

It was on the basis of this small amount of previous research and lack of data concerning edge markings that this study of the effects of pavement edge lines on the lateral placement of vehicles on various pavements widths was developed.

In the overall field of lateral placement, numerous investigations have been made concerning the lateral placement of vehicles under many different conditions. F. H. Green of Purdue University investigated a method of determining lateral placement by photographic means (2). Overmeyer (7), Lang (4), Quimby (8), and Wilson (15) while graduate students at Purdue investigated the effects of various roadway conditions on the lateral placement of vehicles. Other studies have been made by Norman (6), and Taragin (10), (12), of the Bureau of Public Roads; and Case, Hulbert, Mount and Brenner of the University of California (1). These studies, however, did not concern themselves with the same factors investigated here, and, therefore, the results cannot be compared with the results obtained in this study.

PURPOSE

The purposes of this study were to:

(1) Investigate the lateral placement of vehicles on abutting sections of portland cement concrete pavement and bituminous concrete pavement of the same highway, and determine what effect, if any, these two pavement types have on the lateral position of a vehicle.

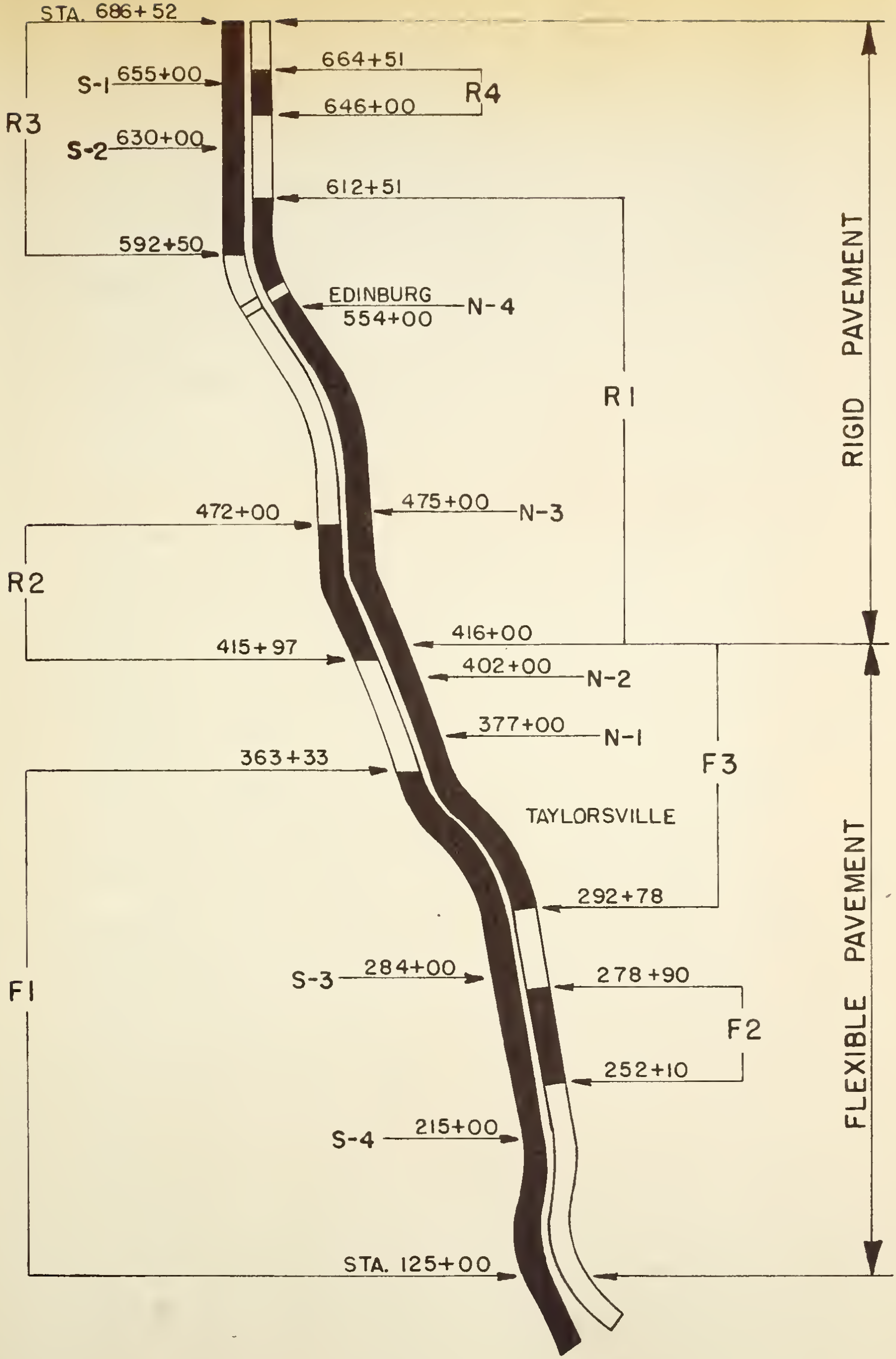
(2) Investigate the lateral placement of vehicles on two-lane bituminous highways with widths of 20', 22', and 24', both before and after the placement of pavement edge lines, and determine what effect, if any, pavement edge lines have on the lateral placement of vehicles when applied to these various widths of two-lane bituminous highways.

SCOPE

In order to properly analyze the factors investigated in this study, the test locations selected for the purpose of data collection had to be chosen so that any other variables aside from those considered in the study would be nullified by the similarity of locations. Among the variables which had to be considered in selecting these locations were highway alinement, traffic volume, roadside culture, shoulder conditions, pavement condition and pavement markings.

In the portion of this study devoted to the effects of pavement type, another factor had to be taken into account when determining locations for data collection. As was previously stated, the results of this study were to be used to determine the reproducibility of the results and conclusions of Rosenfield's study of the same factor. Consequently, test locations were selected on the same section of highway where the data for Rosenfield's study were collected. This section of highway is the U. S. 31 Test Road which is a 4-lane divided highway with 24' pavements extending from a point 1.8 miles north of Columbus, Indiana, north to a point 2.8 miles north of the Bartholomew-Johnson County Line. This Test Road has the additional feature of having abutting sections of portland cement concrete and bituminous concrete pavement. All test locations were selected and located on level and tangent sections of highway bordered by farmland and had no entrances such as roads or drives within 500' of each test site. After a preliminary selection of test locations had been made, representatives from Purdue University, the Portland Cement Association, the Asphalt Institute and the State Highway Department of Indiana made a field inspection trip and selected the final locations. These test locations are shown in Figure 1. Four test sites were located on each type of pavement, two on the southbound lane and two on the northbound lane. The four test sites on the portland cement concrete are designated in Figure 1 as S-1, S-2, N-3, and N-4. Similarly, the four test sites on the bituminous concrete are designated as N-1, N-2, S-3 and S-4. At each of these locations, a sample of 100 passenger cars and 50 semi-trailer trucks was taken during the day as well as at night. Included in the passenger car category were only those vehicles classed as passenger automobiles. Pick-up trucks, passenger cars pulling trailers or other vehicles of this type were not considered. Semi-trailer trucks included any multi-unit vehicle, such as, tractor-trailers, truck-trailers and other multi-unit combinations. When the data were collected, the specific site was chosen at random with the limitation that they had to alternate between pavement type and direction. A list of the sequence in which the sites were visited and the dates and times at which the data were collected appears in Table 21.

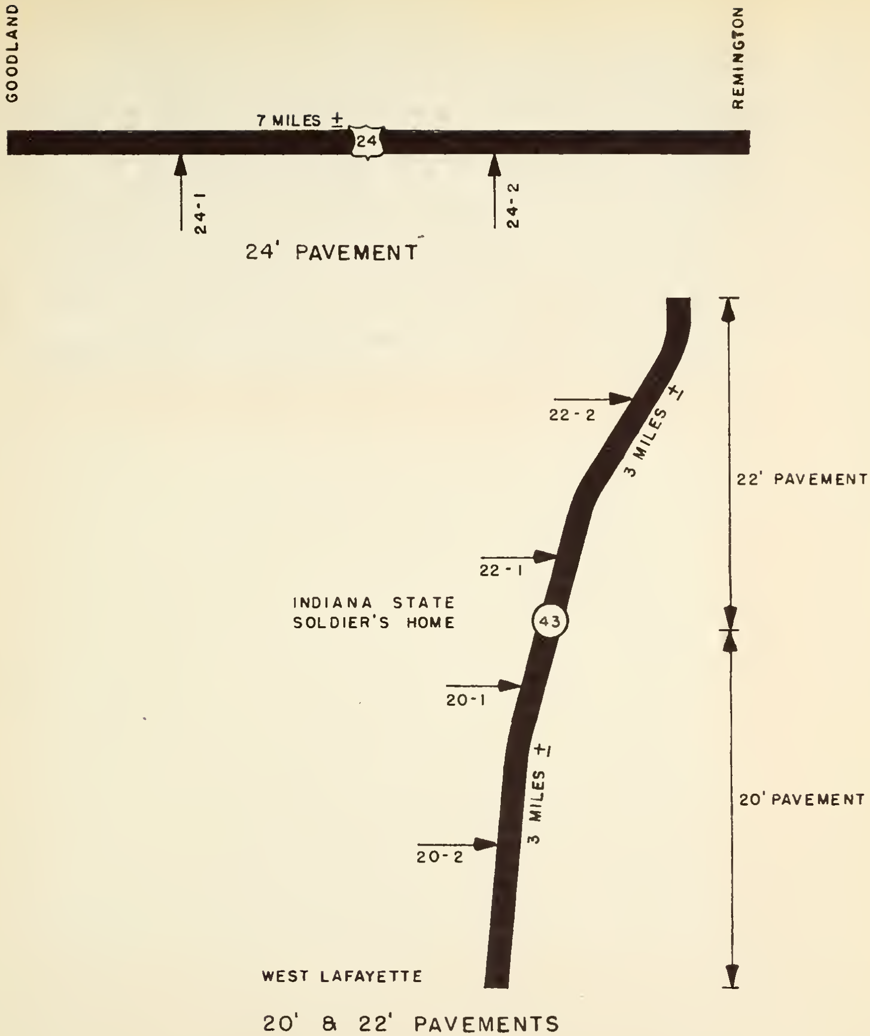
For the portion of this project devoted to the study of the effect of pavement edge lines the same criteria were used



TEST LOCATIONS-US 31

FIGURE 1

in selecting the test locations as was previously stated. To facilitate data collection, an attempt was made to select sections of highway near the Lafayette area for test locations. The test locations for this portion of the study are shown in Figure 2. State Road 43, extending from the north city limit of West Lafayette north to the Tippecanoe County Line was chosen for test sites for the 20' and 22' pavements. These are designated in Figure 2 as 20-1 and 20-2 for the 20' pavement, and 22-1 and 22-2 for the 22' pavement. Route U.S. 24 between Goodland, Indiana, and Remington, Indiana, was chosen for location of test sites for the 24' pavement. These are shown in Figure 2 and designated as 24-1 and 24-2. Both SR 43 and U.S. 24 have a bituminous concrete surface and sod shoulders in good condition. The test sites on these sections of highway were also located on level and tangent sections of highway having farmland immediately adjacent to the right-of-way. At the test sites on the 20' and 22' pavements a sample of 100 passenger cars was taken during the day and again at night before and after the placement of the pavement edge lines. Commercial vehicles, such as, semi-trailer trucks and buses, were not included in this portion of the study because of the low volume of this type of traffic using this road. At the test sites on the 24' pavement, a sample of 100 passenger cars and 50 trucks was taken during the day and 100 passenger cars and 40 trucks at night both before and after the placement of the edge lines. A smaller sample of trucks was taken at night be-



TEST LOCATIONS - SR 43 & US 24

FIGURE 2

cause of the comparatively low volume of vehicles of this type traveling on this highway at night.

The data for the before portion of this study were collected during July, 1957. When the before study was completed, the State Highway Department painted the pavement edge lines on these two sections of highway. The edge lines were painted during August, 1957, and the after study was performed during September, 1957. Figures 3, 4, 5, and 6 show before and after photographs taken at test sites on each of the pavement widths.

BEFORE AND AFTER PHOTOS AT TEST SITE 20-1-SR 43

FIGURE 3

BEFORE AND AFTER PHOTOS AT TEST SITE 22-1-SR 43

FIGURE 4

BEFORE AND AFTER PHOTOS AT TEST SITE 24-1-US 24

FIGURE 5

BEFORE AND AFTER PHOTOS AT TEST SITE 24-2-US 24

FIGURE 6

turn connected to an Esterline-Angus 20-Pen Graphic Recorder. This equipment, its components and operation, are discussed in detail in the following section.

The lateral placement detector was attached to the road by means of heavy industrial tape, two inches in width. On the bituminous concrete, black tape was used and on the portland cement concrete white tape was used. In collecting data on the four-lane divided highway, the placement detector was extended across the inside lane by means of a dummy detector of the same dimensions as the placement detector. Figures 7 and 8 show the detector in place on the roadway at one of the test sites. When the detector had been attached to the pavement, the control board and the Graphic Recorder were placed on a table along with the power source at a location in an adjacent field where the observers were hidden from passing motorists and in all cases not less than 30' from the edge of the pavement. The observers' vehicle was also hidden so that it would not have any adverse effect on vehicles passing the test site. Having the observers and their vehicle concealed gave positive assurance that passing motorists were not aware that their vehicles were under observation. After all the equipment had been connected, the lateral placement detector was tested to insure that it was in proper working order. Before the observations were begun, a wind anemometer and a wind vane were set up in a position which would give velocity and direction of any wind striking the passing vehicles. However, they also were located so that they would not be ef-

LATERAL PLACEMENT DETECTOR ON ROADWAY

AT TEST SITE 24-2-US 24

FIGURE 7

LATERAL PLACEMENT DETECTOR AS IT APPEARED

TO DRIVERS 25' FROM THE TEST SITE

FIGURE 8

fected by wind disturbances caused by these vehicles. A magnetic compass was used to determine the bearing of the road at the test site and to orient the wind vane for the particular location.

Upon completion of all of these necessary preliminaries, observations were begun. Summary sheets were employed for the purpose of tabulating the data as it appeared on the Graphic Recorder. This eliminated the tedious job of extracting the data from the recorder tapes at some latter date after the observations were taken and also eliminated the possibility of any errors which could occur in extracting this data. Recorded on these summary sheets were the type of vehicle and the one-foot increment in which the right wheel of the vehicle crossed the lateral placement detector. These sheets also included other pertinent data such as, the date, weather, the times that the observations began and ended, the test site code number, and recordings of the wind velocity and direction. The wind readings were taken at the start and finish of the study and at each 15 minute interval during the study. Also, any unusual wind disturbances occurring between intervals were recorded.

When the appropriate number of observations had been made, the equipment was removed until the same night when the night observations were taken. Only one test site was visited a day in order that the night data could be collected on the same date, and, consequently, with conditions as similar as possible for both periods.

EQUIPMENT

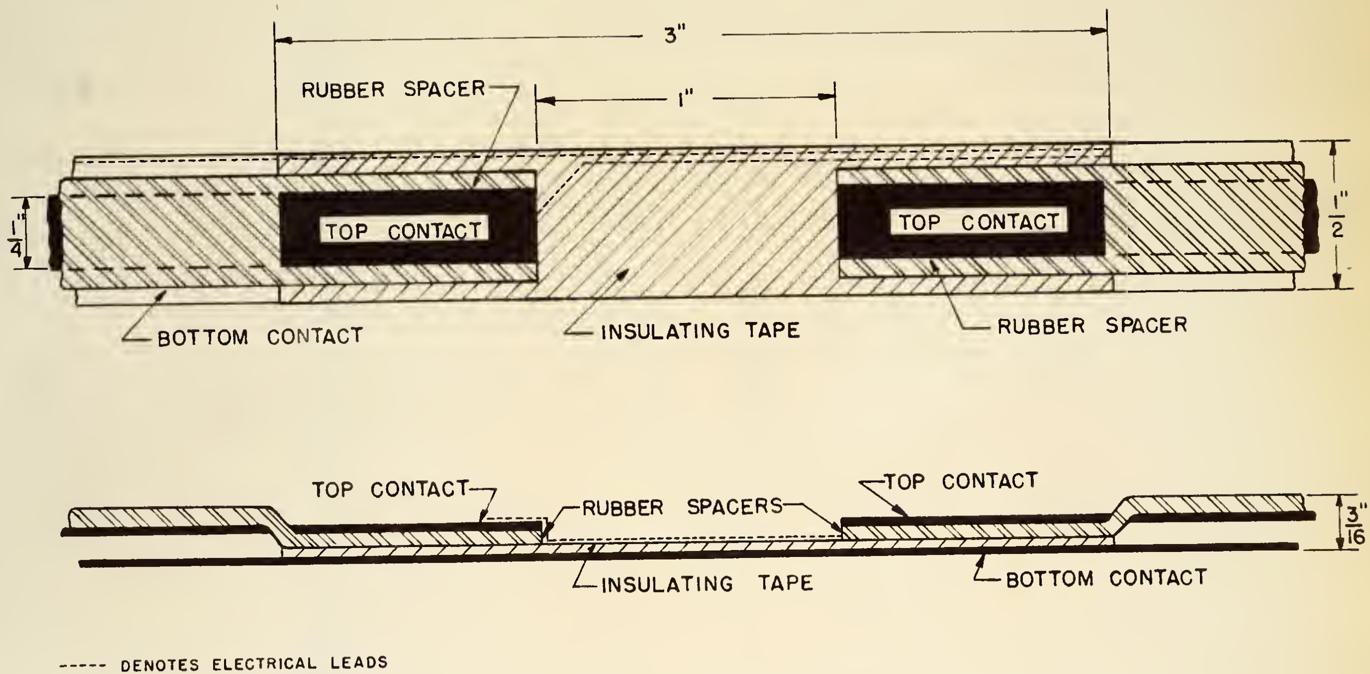
At the beginning of this study, a thorough investigation had to be made to determine what method whould be employed to determine the lateral position of a vehicle on the roadway. Of the three methods available, photographic, visual, and traffic actuated, the traffic-actuated method was chosen. This method was decided upon because of its versatility, relative inexpensiveness, and its proven reliability.

The device employed in this study was a segmented electrical detector similar to the detector developed by Holmes and Reymer of the Bureau of Public Roads (3) and further improved by Mathewson, Brenner, and Riess of the Institute of Transportation and Traffic Engineering at the University of California (5). This detector, essentially, was constructed of two metal strips, one continuous bottom strip, and twelve individual top segments separated from the bottom strip by rubber spacers. The bottom strip, extending the full length of the detector, was a 12' length of spring steel, 1/2 inch in width and .015 of an inch thick. The top segments were each 11 inches long and consisted of strips of spring steel 1/4 inch wide and .01 of an inch thick. These top contacts were separated from the bottom contact for a length of 1 inch on each end and 1/2 inch in the center by insulating tape and gum rubber. These separations were necessary to assure that the top segments would be in contact with the bottom strip only while the wheels of the vehicle were passing over the detector. The internal details of the detecting element as constructed are shown in

Figure 9. The 1-inch gap between the ends of the top segments was provided for the purpose of making the necessary electrical connections. A separate electrical lead consisting of No. 18 covered copper wire was connected to each of the top elements, and one lead was connected to the common bottom strip. After completion of the internal construction, the entire detector was covered with heavy industrial tape, coated with rubber cement, and then recovered with the same heavy tape. Figure 10 shows a cut-away section of the completed detector unit.

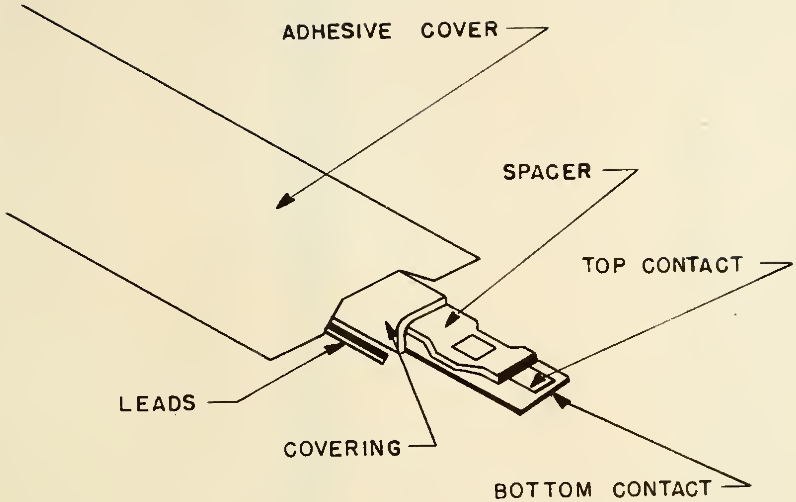
A 50' length of rubber tubing was used to carry the thirteen leads from the detector to a control board. From the control board, the twelve leads for the top contacts were connected to pens No. 1 to No. 12 on an Esterline-Angus 20-Pen Graphic Recorder. The lead from the bottom contact was connected to the common or ground of the circuit. Two six-volt acid batteries were used to supply the necessary 8-volts D.C. to operate the recorder.

After the detector was in place and connected to the recorder, the equipment operated in the following manner. When a vehicle crossed the detector in the one-foot increment closest to the pavement edge, the first contact was closed, and, consequently, actuated pen No. 1 on the recorder. When a vehicle crossed the detector between 2' and 3' from the pavement edge, the third contact was closed, and, consequently, actuated pen No. 3 on the recorder. Figure 11 shows the manner in which the top contacts covered the twelve one-foot zones of the pavement surface.



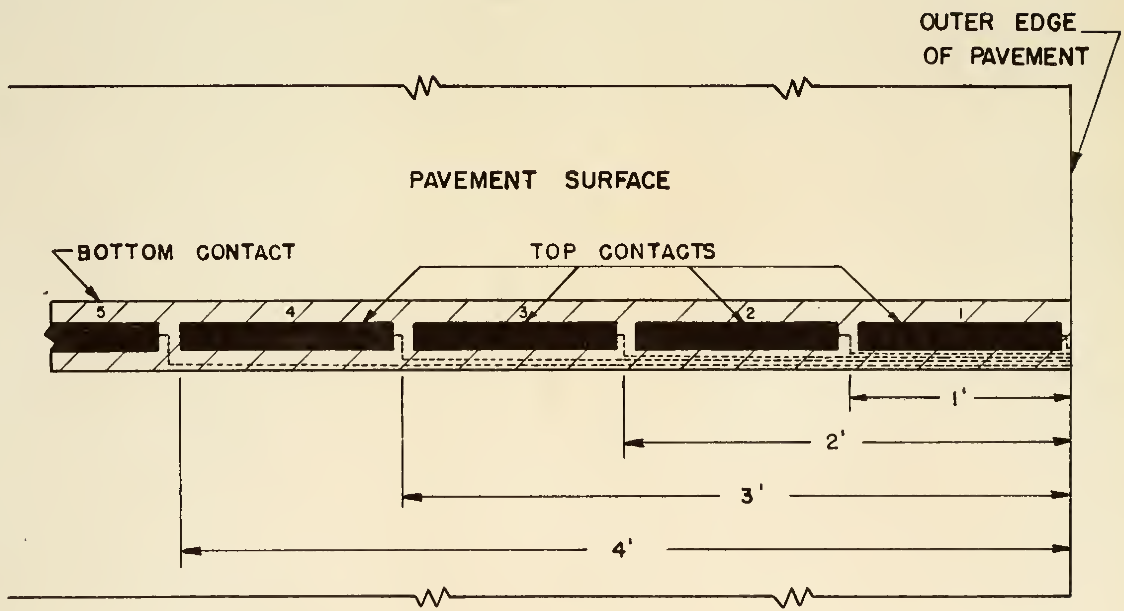
DETAILS OF THE SEGMENTED ELEMENT

FIGURE 9



DETAILS OF THE DETECTOR STRIP

FIGURE 10



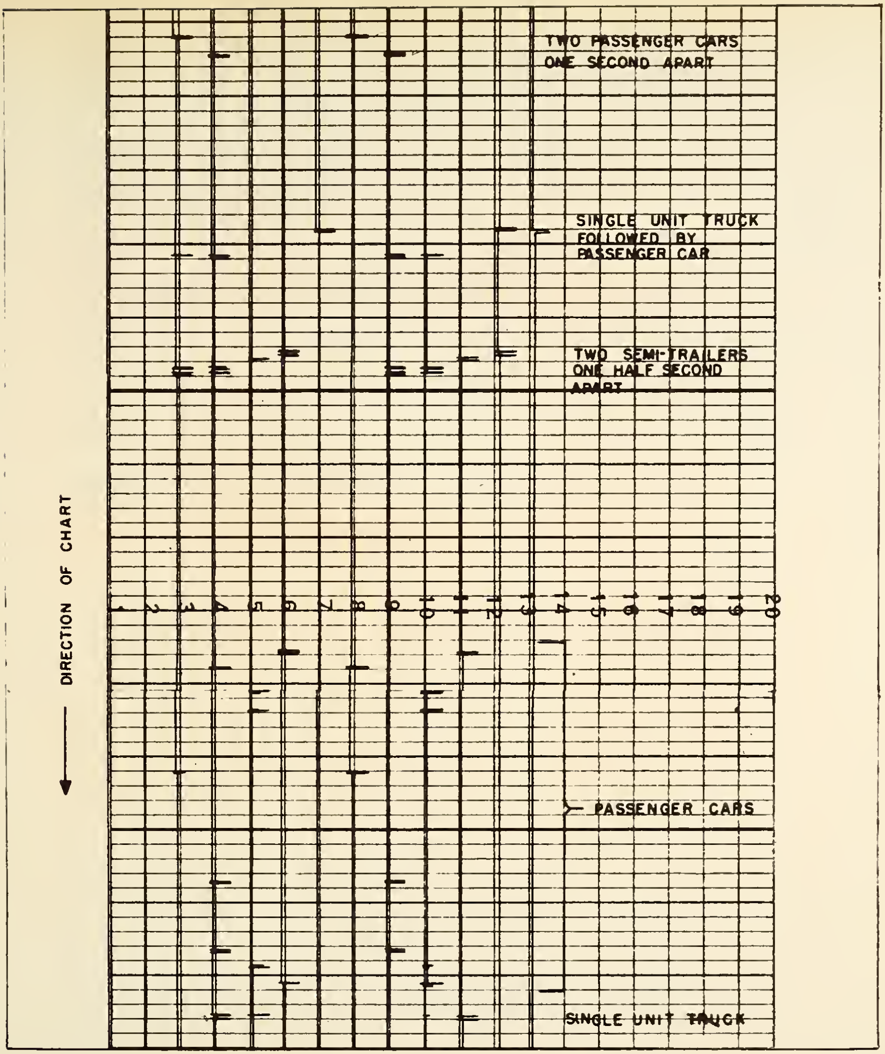
-------- DENOTES ELECTRICAL LEADS

DETAIL OF ZONES COVERED BY EACH TOP CONTACT

FIGURE 11

The instrument which recorded the lateral placement data was a standard, heavy duty, Esterline-Angus Model A.W., 20 Pen Operation recorder having a spring wound chart drive and switch type operation with a common return circuit. This recorder, upon receiving positive actuation from the electrical detector, reacted instantaneously and recorded these actuations by means of continuous writing pens on a chart moving at a constant speed. Because the normal tread width of vehicles is 5', the detector ordinarily received two actuations and in some cases four actuations. A typical section of chart from the recorder is shown in Figure 12. The speed of the chart while observations were being made was 6 inches per minute and by close inspection of the figure it can be seen that heavy volumes of traffic could be handled by the recorder at this speed. Because of its instantaneous reaction to actuation and its continuous recording properties, the graphic recorder provided for recording large and concentrated volumes of traffic and allowed the observer to stop the instrument temporarily to tabulate these data.

For purposes of recording the wind data during the period of observation, a Bunge Cup wind anemometer was used for wind velocity, and an electrical wind vane was used for wind direction. The Bunge Cup wind anemometer was calibrated in such a manner that wind velocities ranging from 0-60 miles per hour could be recorded. The wind velocities could be read directly from the scale on the anemometer. The electrical wind vane employed for determining the direction of the wind consisted of an ordinary



NOTES:

1. ACTUATIONS ON LINE 13 INDICATE WHEN VEHICLES IN OTHER LANE PASSED DETECTOR
2. CHART SPEED 6 INCHES PER MINUTE
3. EACH CHART DIVISION EQUALS ONE SECOND IN TIME

TYPICAL SECTION OF GRAPHIC RECORDER CHART

FIGURE 12

pointer wind vane connected to a dial containing 8 electric bulbs indicating the 8 major directions. The electrical connections of the wind vane were so arranged that when the wind was from a direction between two of the 8 major directions, two bulbs would light. This essentially provided for recording the direction of the wind from any one of the 16 points on a compass or to an accuracy of 22.5°. The 6-volt D.C. required to operate the wind vane was tapped from the power source of the recording equipment. Figures 13 and 14 show the lateral placement and wind equipment in place at a test site.

RECORDING EQUIPMENT IN PLACE IN THE FIELD

FIGURE 13

BUNGE CUP WIND ANEMOMETER AND

ELECTRICAL WIND VANE

FIGURE 14

STATISTICAL ANALYSIS AND RESULTS

EFFECT OF PAVEMENT TYPE

GENERAL REMARKS

In this portion of the study, an investigation was made to determine if the type of pavement, portland cement concrete or bituminous concrete, had any effect on the lateral placement of passenger cars and semi-trailer trucks. Other factors, which were also investigated, included direction of travel and period of observation. The direction of travel was divided into North and South and the period of observation into day and night.

After completion of the field sampling, the data were taken from the summery sheets and compiled into a form lending itself more readily to analysis. This is shown in Tables 1 and 2, which contain frequency distributions of the data for each location and condition. To further facilitate the analysis, these distributions were transformed into frequency polygons, as shown in Figures 15 and 16. These frequency polygons show graphically the distribution of the lateral placement data and means at each location for each condition. From these distributions statistical data were obtained for purposes of making the analysis. Tables 3 and 4 list a summary of this data for each vehicle type for all locations. This data consists of the mean lateral placement, which is the arithmetic mean of the measured variable; the variance, which is a measure of dispersion

Table 1

DISTRIBUTION OF LATERAL PLACEMENT IN ONE-FOOT SECTIONS

FROM OUTER EDGE OF PAVEMENT TO RIGHT WHEEL OF VEHICLES - US 31

-Passenger Cars-

Location and Condition		One-Foot Sections From Outer Edge of Pavement 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Total
S-1	Day	-	-	-	20	38	29	11	2	-	100
	Night	-	-	4	15	47	26	7	1	-	100
S-2	Day	-	-	6	13	47	26	7	1	-	100
	Night	-	-	1	9	36	39	15	-	-	100
N-3	Day	-	-	3	14	49	31	3	-	-	100
	Night	-	1	-	22	45	24	8	-	-	100
N-4	Day	-	-	1	5	22	50	22	-	-	100
	Night	-	-	-	6	29	53	11	1	-	100
N-1	Day	-	-	1	16	33	36	14	-	-	100
	Night	-	-	3	6	15	53	20	3	-	100
N-2	Day	-	-	2	23	42	25	5	1	-	100
	Night	-	-	9	15	37	29	9	1	-	100
S-3	Day	-	2	6	14	30	36	12	-	-	100
	Night	-	2	2	10	30	37	19	-	-	100
S-4	Day	-	-	1	16	33	36	14	-	-	100
	Night	-	-	3	6	15	53	20	3	-	100

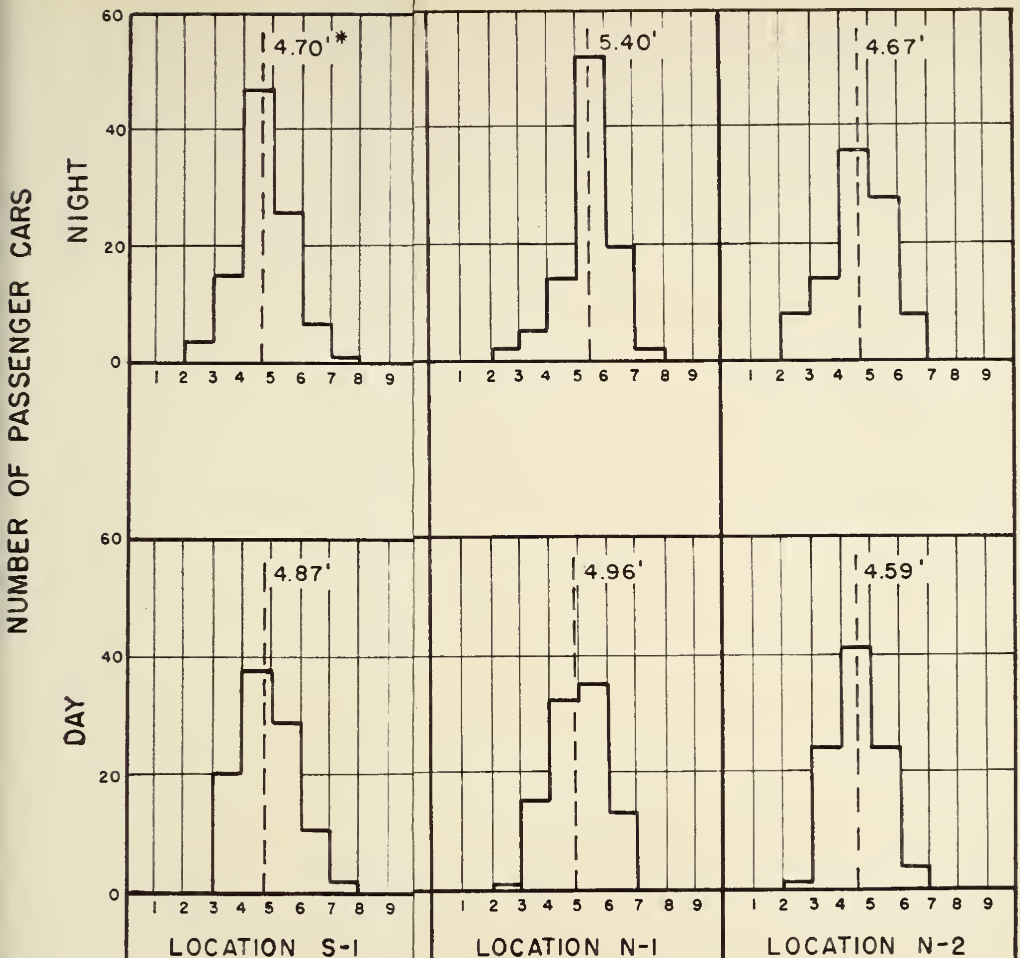
Table 2

DISTRIBUTION OF LATERAL PLACEMENT IN ONE-FOOT SECTIONS

FROM OUTER EDGE OF PAVEMENT TO RIGHT WHEEL OF VEHICLE - US 31

-Semi-Trailer Trucks-

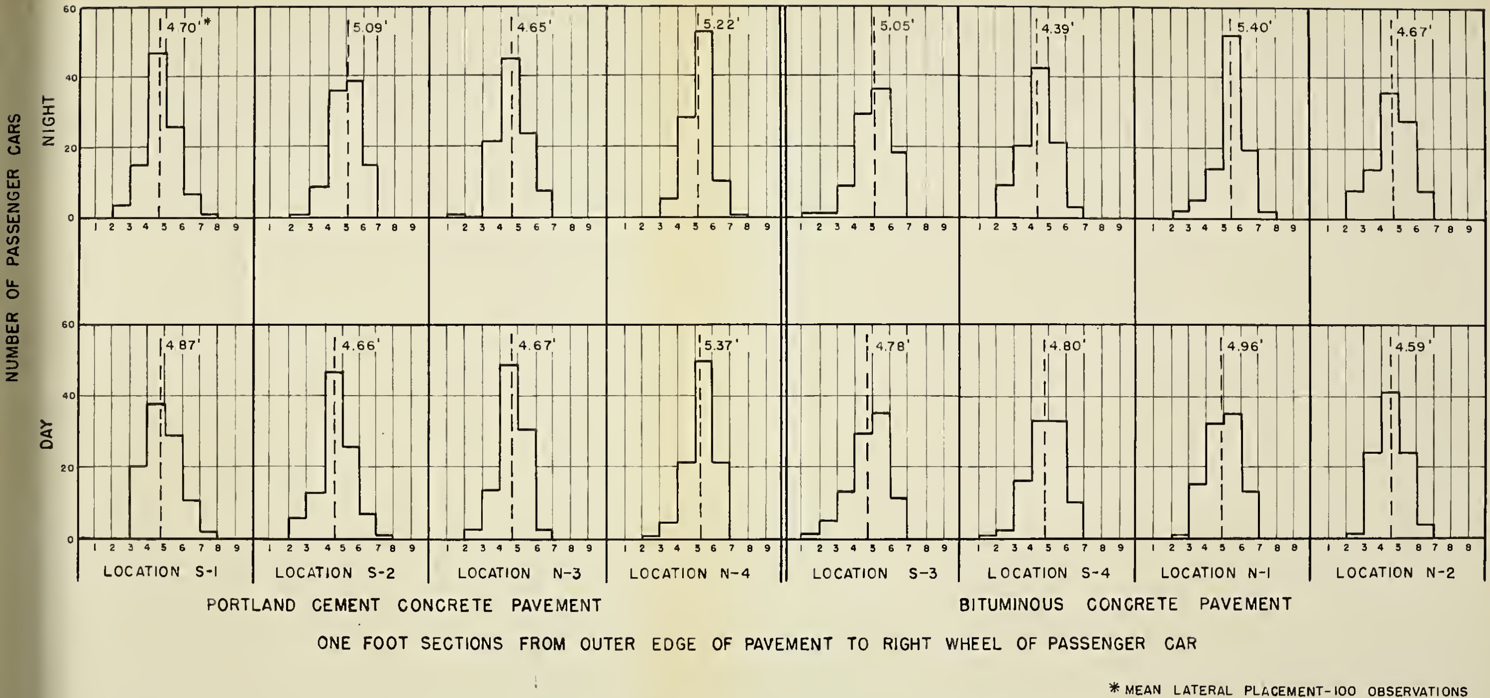
Location and Condition	One Foot Section From Outer Edge of Pavement 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	Total
S-1 Day	-	2	27	08	3	-	-	-	50
Night	-	5	30	12	3	-	-	-	50
S-2 Day	-	2	29	18	1	-	-	-	50
Night	-	1	20	22	7	-	-	-	50
N-3 Day	4	1	19	18	7	1	-	-	50
Night	-	1	17	25	5	2	-	-	50
N-4 Day	-	1	15	26	8	-	-	-	50
Night	-	2	16	21	10	1	-	-	50
N-1 Day	1	5	29	13	3	-	-	-	50
Night	-	1	19	21	6	3	-	-	50
N-2 Day	-	6	30	12	2	-	-	-	50
Night	-	1	17	24	7	1	-	-	50
S-3 Day	-	8	29	8	5	-	-	-	50
Night	-	4	28	12	6	-	-	-	50
S-4 Day	1	5	27	12	4	1	-	-	50
Night	-	4	27	16	3	-	-	-	50



PORTCRETE PAVEMENT

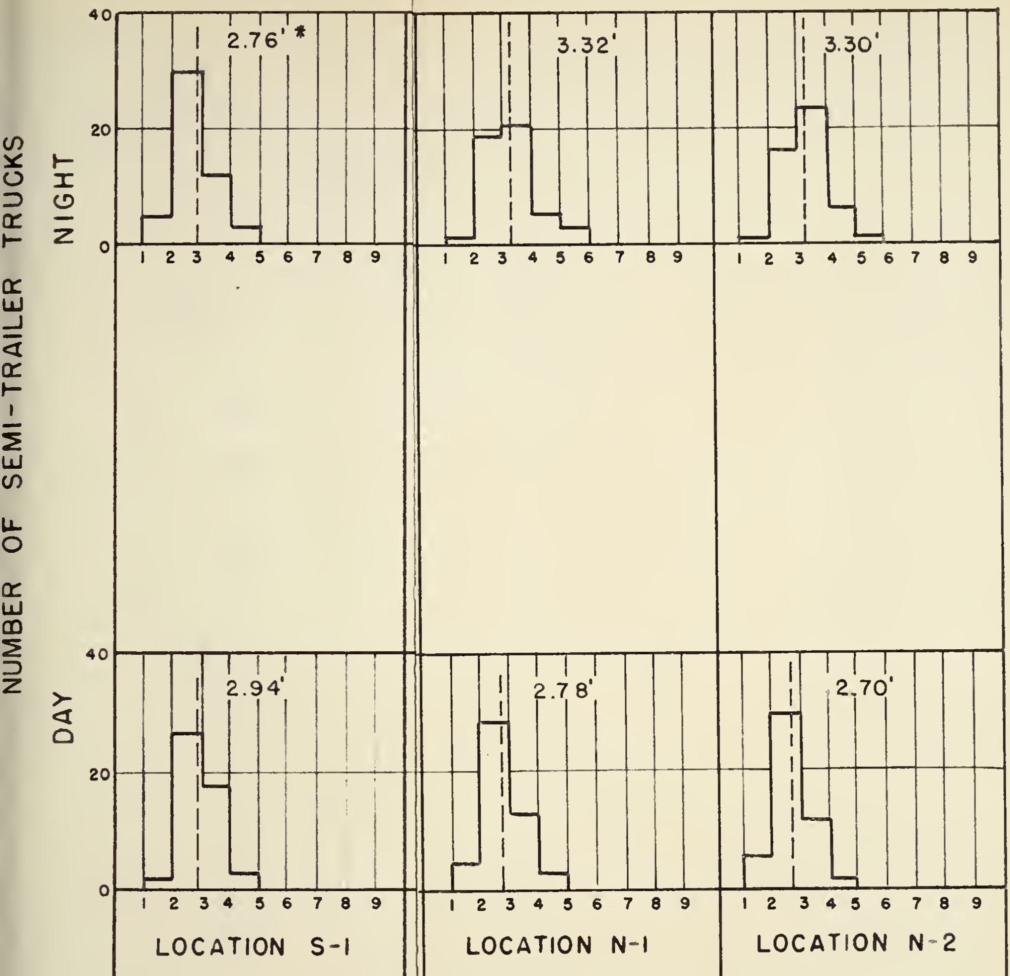
ER CAR

MEAN LATERAL PLACEMENT-100 OBSERVATIONS



FREQUENCY POLYGONS, PASSENGER CARS – US 31

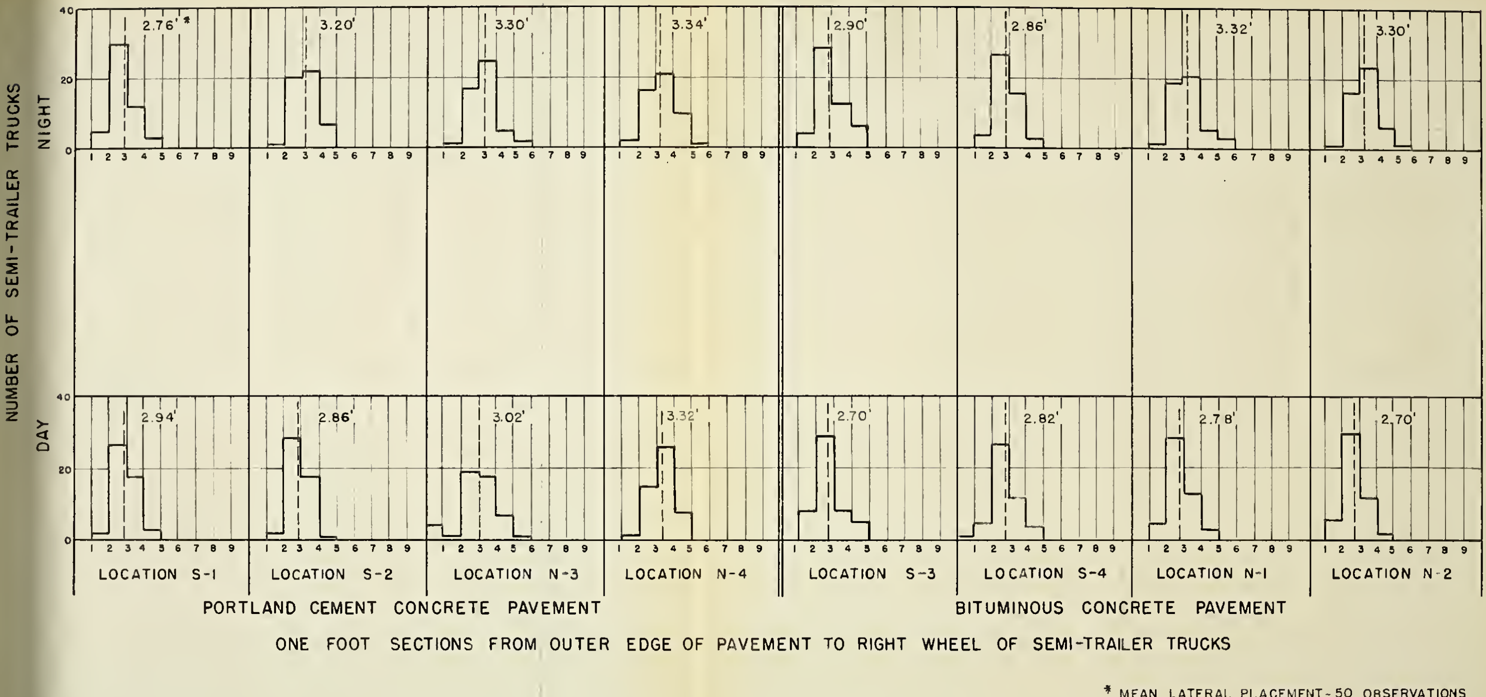
FIGURE 15



PORTLRETE PAVEMENT

ER TRUCKS

IEAN LATERAL PLACEMENT - 50 OBSERVATIONS



FREQUENCY POLYGONS, SEMI-TRAILER TRUCKS – US 31

FIGURE 16

Table 3

SUMMARY OF STATISTICAL DATA - US 31

-Passenger Cars-

Location and Condition		Mean	Variance	Standard Deviation
S-1	Day	4.87	0.9627	0.9812
	Night	4.70	0.9091	0.9535
S-2	Day	4.66	0.9774	0.9886
	Night	5.09	0.7915	0.8896
N-3	Day	4.67	0.6678	0.8172
	Night	4.65	0.8561	0.9253
N-4	Day	5.37	0.7203	0.8487
	Night	5.22	0.6077	0.7796
N-1	Day	4.96	0.9176	0.9579
	Night	5.40	0.9798	0.9898
N-2	Day	4.59	0.8706	0.9331
	Night	4.67	1.2334	1.1106
S-3	Day	4.78	1.3349	1.1554
	Night	5.05	1.1995	1.0952
S-4	Day	4.80	1.0808	1.0395
	Night	4.39	0.9878	0.9939

Average Mean:	Portland Cement Concrete, Day	4.90'
	Portland Cement Concrete, Night	4.92'
	Bituminous Concrete, Day	4.78'
	Bituminous Concrete, Night	4.88'

Table 4

SUMMARY OF STATISTICAL DATA - US 31

Semi-Trailer Trucks

Location and Condition		Mean	Variance	Standard Deviation
S-1	Day	2.94	0.4555	0.6749
	Night	2.76	0.5229	0.7231
S-2	Day	2.86	0.3576	0.5980
	Night	3.20	0.5408	0.7354
N-3	Day	3.02	1.1935	1.0924
	Night	3.30	0.6531	0.8081
N-4	Day	3.32	0.5180	0.7197
	Night	3.34	0.7497	9.8657
N-1	Day	2.78	0.5322	0.7295
	Night	3.32	0.8037	0.8965
N-2	Day	2.70	0.4898	0.6999
	Night	3.30	0.6122	0.7824
S-3	Day	2.70	0.6939	0.8330
	Night	2.90	0.6531	0.8081
S-4	Day	2.82	0.8343	0.9134
	Night	2.86	0.5208	0.7217

Average Mean:	Portland Cement Concrete, Day	3.04'
	Portland Cement Concrete, Night	3.15'
	Bituminous Concrete, Day	2.75'
	Bituminous Concrete, Night	3.10'

of the individual observations and is equal to the sum of the squares of the deviation of the individual observations from their mean divided by the number of observations; and the standard deviation, which is another measure of variation and is equal to the square root of the variance.

Before these data could be used to study the factors being investigated in this study, they had to be tested to determine whether the assumptions necessary for a statistical analysis of variance could be made. These assumptions are that the variable being studied has a normal distribution and that the variances are homogeneous. These data were tested for homogeneity by means of a Bartlett Test. It was found that the variances were not homogeneous, and, therefore, the data could not be used until a transformation of the original variable to another variable was made to compensate for the lack of homogeneity. This was accomplished by replacing the variances by their logarithms and carrying out the analysis on these. This procedure is used throughout this analysis in examining the variances. No adjustments were made for the non-normality of the measured variable, for deviations from normality are not as serious in upsetting the probability levels chosen for significance as are gross departures from homogeneity of variance.

After the data had been compiled and transformed to make it suitable for investigation of the factors being studied, analyses were made on the mean lateral placement, the logarithms of the variances, and the percents of vehicles in specific zones of the pavement. These analyses were made according to the following mathematical model:

$$Y_{ijkl} = \mu + T_i + D_j + L_{k(ij)} + TD_{ij} + P_l + TP_{(il)} + DP_{(jl)} + TDP_{(ijl)} +$$

$$PL_{lk(ij)}.$$

Where

μ	=	Overal Average Effect	
T	=	Type of Pavement	i = 1, 2
D	=	Direction	j = 1, 2
L	=	Location	k = 1, 2
P	=	Period of Observation	l = 1, 2

All factors in this model were considered as fixed effects except locations, which were considered as a random effect. Locations were considered as random in order that the results obtained from the analyses could be used to reach conclusions about all locations along the road or similar roads. If locations were considered as a fixed effect, the results of the analyses could be used only to reach conclusions about those particular locations and no others.

STUDY OF MEAN LATERAL PLACEMENTS

The first step in the study of the mean lateral placements is to perform an analysis of variance on the individual means. If in an analysis of variance of this type certain factors are found to be significant, further analysis is carried out. If, on the other hand, no significant difference is found between the factors being investigated, further analysis is deemed unnecessary.

PASSENGER CARS - The summary of the analysis of variance on the mean lateral placements of passenger cars is listed in Table 5. Figure 17 shows a graphical representation of the mean lateral placement at all locations for both day and night.

The results of this analysis show that none of the major factors investigated nor any of the accompanying interactions have any significant effect on the mean lateral placement of passenger cars. This is true for both types of pavement in both directions during the day and at night. This may be seen more readily by inspection of the average means for the two types of pavement, the two directions, and the two periods of observation tabulated in Table 6. In Figure 17, it can be seen that the means vary from location to location. However, these variations are not deemed critical and are attributed entirely to the natural variation, which occurs because of the random sampling methods used in collecting the data.

SEMI-TRAILER TRUCKS - The summary of the analysis of variance on the mean lateral placements of semi-trailer trucks is listed in Table 7. A graphical representation of the mean lateral placements appears in Figure 18.

The results of this analysis show that the only significant differences which occur are between the directions of travel, North and South, and the periods of observation, day and night, when pavement type is not considered. By inspection of the summary of average means in Table 8, it can be seen that the northbound mean is significantly greater than the south-

Table 5

SUMMARY OF THE ANALYSIS OF VARIANCE

ON MEAN LATERAL PLACEMENT - US 31

-Passenger Cars-

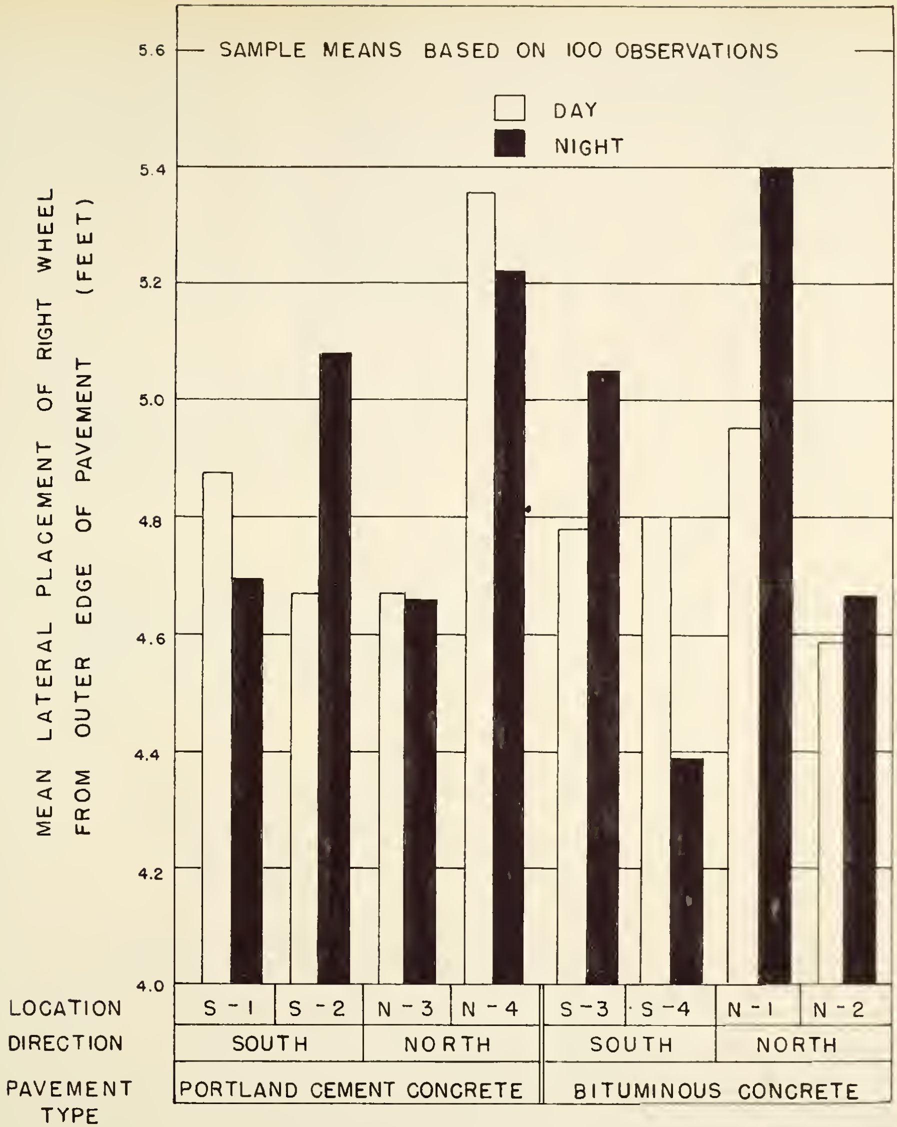
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.010000	.010000	1	NS
Direction	1	.297025	.297025	1.022	NS
Period	1	.019600	.019600	1	NS
Location in Type by Direction	4	1.162150	.290538	--	--
Type by Direction	1	.060025	.060025	1	NS
Type by Period	1	.108900	.108900	1	NS
Direction by Period	1	.099225	.099225	1	NS
Type by Direction by Period	1	.000225	.000225	1	NS
Period by Location in Type by Direction	4	.768540	.192112	--	--

Notes - - -

*Rejection of The Hypothesis That There Are No Population Differences At The 5% Level of Significance.

**Rejection of The Hypothesis That There Are No Population Differences At The 1% Level of Significance.

NS Acceptance Of The Hypothesis Of Eqral Population Means.



MEAN LATERAL PLACEMENT
PASSENGER CARS — US 31

FIGURE 17

Table 6

AVERAGE MEANS - US 31

-Passenger Cars-

Portland Cement Concrete, Day -	4.90
Portland Cement Concrete, Night -	4.92
Bituminous Concrete, Day -	4.78
Bituminous Concrete, Night -	4.88
Northbound, Portland Cement Concrete -	4.96
Southbound, Portland Cement Concrete -	4.84
Northbound, Bituminous Concrete -	4.91
Southbound, Bituminous Concrete -	4.76
Portland Cement Concrete -	4.91
Bituminous Concrete -	4.84
Northbound -	4.94
Southbound -	4.80
Day Observations -	4.85
Night Observations -	4.89

Table 7

SUMMARY OF THE ANALYSIS OF VARIANCE

ON MEAN LATERAL PLACEMENT - US 31

-Semi-Trailer Truck-

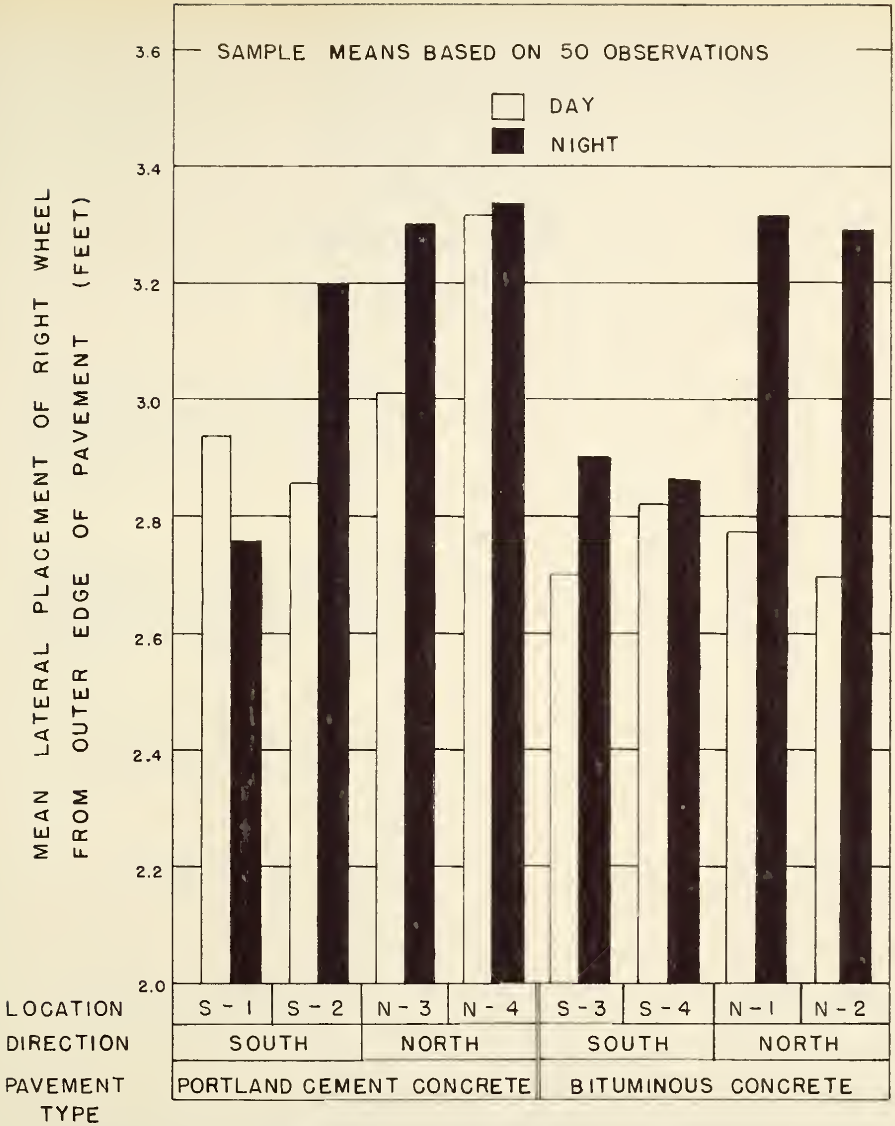
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.1156	.1156	7.049	[illegible]
Direction	1	.2601	.2601	15.860	[illegible]
Period	1	.2116	.2116	9.200	*
Location in Type by Direction	4	.0654	.0164	--	--
Type by Direction	1	.0100	.0100	1	[illegible]
Type by Period	1	.0529	.0529	2.300	NS
Direction by Period	1	.0676	.0676	2.939	[illegible]
Type by Direction by Period	1	.0361	.0361	1.570	[illegible]
Period by Location in Type by Direction	4	.0918	.0230	--	--

Notes: - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level of Of Significance.

NS Acceptance Of The Hypothesis Of Equal Population Means.



MEAN LATERAL PLACEMENT
SEMI-TRAILER TRUCKS - US31

FIGURE 18

Table 8

AVERAGE MEANS - US 31

Semi-Trailer Trucks

Portland Cement Concrete, Day	3.04'	
Portland Cement Concrete, Night	3.15'	
Bituminous Concrete, Day	2.75'	
Bituminous Concrete, Night	3.10'	
Northbound, Portland Cement Concrete	3.25'	
Southbound, Portland Cement Concrete	2.94'	
Northbound, Bituminous Concrete	3.03'	
Southbound, Bituminous Concrete	2.82'	
Portland Cement Concrete -	3.09'	
Bituminous Concrete -	2.92'	
Northbound -	3.14')	0.26'*
Southbound -	2.88')	
Day Observations -	2.89')	0.23'*
Night Observations -	3.12)	

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

bound mean. This implies that for the eight locations studied, there are real directional differences between means for semi-trailer trucks. Also, in this summary it can be seen that the night mean for semi-trailer trucks is significantly greater than the day mean when the means are averaged across all locations for both directions disregarding pavement type. Therefore, from these results it can be implied that semi-trailer trucks drive farther from the edge of the pavement at night than during the day on both types of pavement in both directions.

STUDY OF VARIANCES

As was previously stated, the location variances were tested for homogeneity by a Bartlett Test. Because it was found that these variances lack homogeneity, the variances were transformed into their logarithms to restore the homogeneity and the analysis was carried out on these.

PASSENGER CARS - A summary of the results of the analysis of variance carried out on the logarithms of the variances for passenger cars is shown in Table 9. Figure 19 shows a graphical representation of the location variances for both periods of observation.

The results of this analysis show that both pavement type and direction have a significant effect on the variability of the lateral placement of passenger cars. These significant differences can be readily seen by examination of the average variances appearing in Table 10. This table shows that the var-

Table 9

SUMMARY OF THE ANALYSIS OF VARIANCE

ON THE LOGARITHMS OF THE VARIANCES - US 31

-Passenger Cars-

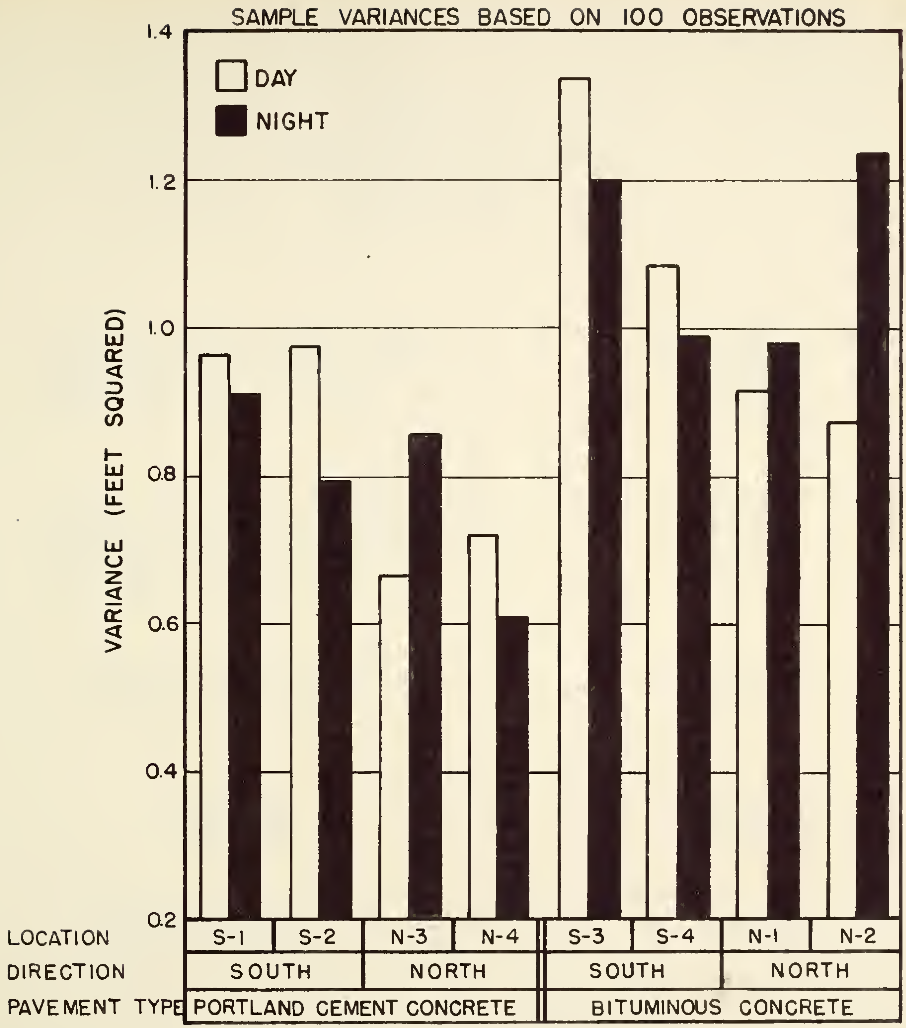
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.061082	.061082	18.350	*
Direction	1	.028935	.028935	8.693	*
Period	1	.000009	.000009	1	NS
Location in Type by Direction	4	.013314	.003328	--	--
Type by Direction	1	.002118	.002118	1	NS
Type by Period	1	.001951	.001951	1	NS
Direction by Period	1	.010808	.010808	3.288	NS
Type by Direction by Period	1	.000823	.000823	1	NS
Period by Location in Type by Direction	4	.013149	.003287	--	--

Notes ---

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



LOCATION VARIANCES
PASSENGER CARS – US 31

FIGURE 19

Table 10

AVERAGE VARIANCES - US 31

Passenger Cars

Portland Cement Concrete, Day	0.83205
Portland Cement Concrete, Night	0.79110
Bituminous Concrete, Day	1.05097
Bituminous Concrete, Night	1.10013
Northbound, Portland Cement Concrete	0.71298
Northbound, Bituminous Concrete	1.00035
Southbound, Portland Cement Concrete	0.91018
Southbound, Bituminous Concrete	1.15075
Portland Cement Concrete	0.81158)*
Bituminous Concrete	1.07555)
Northbound	0.85667)*
Southbound	1.03057)
Day Observations	0.94151
Night Observations	0.94562

Notes --

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

iability of the lateral placement of passenger cars is significantly greater on bituminous concrete than on portland cement concrete when direction of travel and period of observation are not considered. It also shows that the variability is significantly greater in a southbound direction than in a northbound direction when pavement type and period of observation are not considered.

SEMI-TRAILER TRUCKS - Table 11 gives a summary of the results of the analysis of variance on the logarithms of the variance of the lateral placement of semi-trailer trucks. A graphical representation of the variances at each location for each period of observation are shown in Figure 20.

The results of this analysis show that there is no significant effect on the variability by the major factors investigated. However, the interaction effect of type of pavement and direction of travel shows that there is a significant difference between variances in lateral placement when only type of pavement and direction are considered. In the table of average variances (Table 12), it can be seen that there is a rather large variation between the average variances on the two types of pavement in a southbound direction and between the two average variances for northbound and southbound vehicles on portland cement concrete. This interaction effect between pavement type and direction was significant only by a very small margin at the 5% level of significance and since none of the major factors were found significant, it is not deemed critical.

Table 11

SUMMARY OF THE ANALYSIS OF VARIANCE

ON THE LOGARITHMS OF THE VARIANCES - US 31

-Semi-Trailer Trucks-

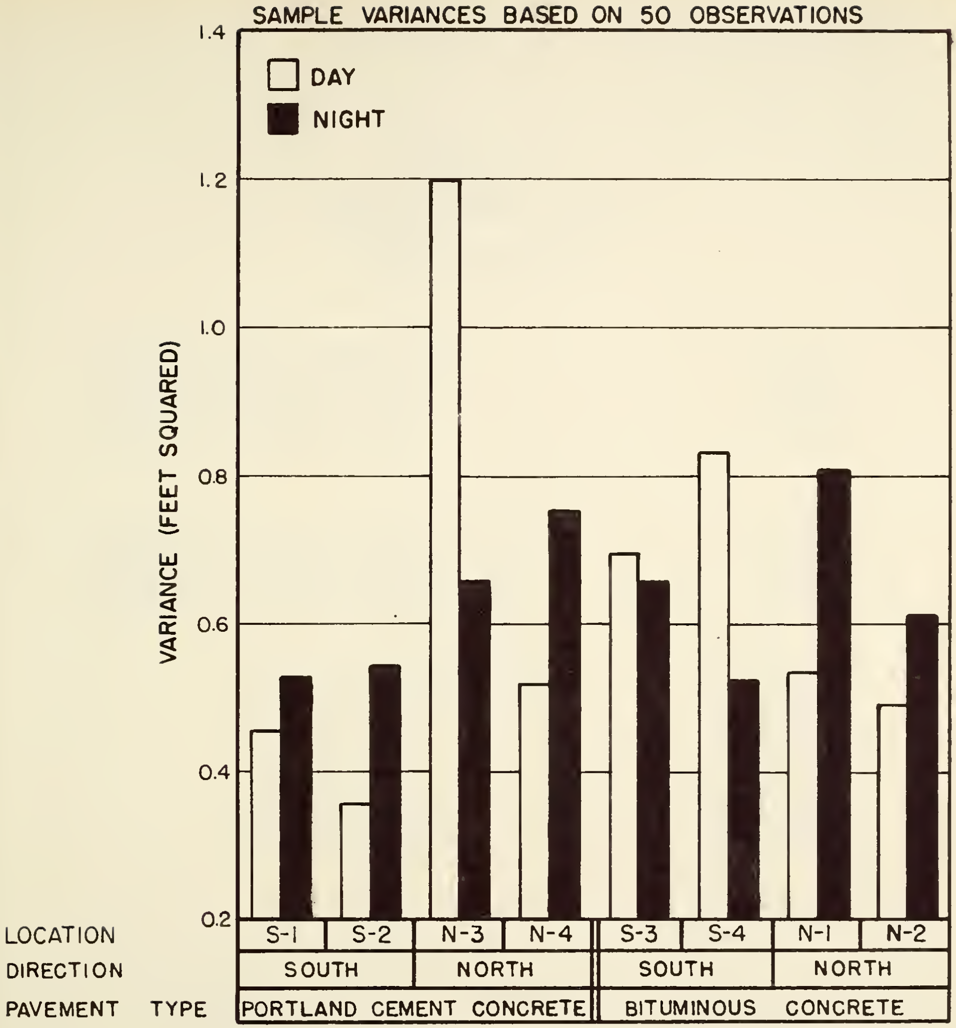
Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.003339	.003339	1	NS
Direction	1	.027084	.027084	3.503	NS
Period	1	.002757	.002757	1	NS
Location in Type by Direction	4	.030929	.007732	--	--
Type by Direction	1	.059620	.059620	7.7105*	$F_{.05}$ 7.71
Type by Period	1	.000274	.000274	1	NS
Direction by Period	1	.001205	.001205	1	NS
Type by Direction by Period	1	.036019	.036019	2.167	NS
Period by Location in Bype by Direction	4	.066474	.016618	--	--

Notes ---

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



LOCATION VARIANCES
SEMI-TRAILER TRUCKS—US 31
FIGURE 20

Table 12

AVERAGE VARIANCES - US 31

-Semi-Trailer Trucks-

Portland Cement Concrete, Day	0.63115
Portland Cement Concrete, Night	0.61655
Bituminous Concrete, Day	0.63755
Bituminous Concrete, Night	0.64745
Northbound, Portland Cement Concrete	0.77850 *
Northbound, Bituminous Concrete	0.60948 *
Southbound, Portland Cement Concrete	0.46920 *
Southbound, Bituminous Concrete	0.67553 *
Portland Cement Concrete	0.62385
Bituminous Concrete	0.64250
Northbound	0.69399
Southbound	0.57237
Day Observations	0.63435
Night Observations	0.63200

Notes ---

* Rejection of The Hypothesis That There Are No Population Differences At The 5% Level of Significance.

STUDY OF VEHICLES IN SPECIFIC ZONES OF THE PAVEMENT

In these analyses of the percents of vehicles in specific zones of the pavement, the same procedure was followed as in the previous analyses. The only difference in these analyses is that of the variable being analyzed, the percents of vehicles in the studied zones. These percents were analyzed for passenger cars in the outer three feet of pavement and more than five feet from the edge of the pavement. Similarly, for semi-trailer trucks, the percents of these vehicles in the outer two feet of pavement and more than four feet from the pavement edge were analyzed.

The percentages for each location and condition are listed in Table 13 and were obtained from the frequency distributions of the lateral placement data in Tables 1 and 2.

Because it was found previously that the homogeneity of variance assumption could not be made, before these analyses could be performed, the original variable had to be transformed into another variable to restore the homogeneity. This was accomplished in this instance by transforming the percents into arc-sine values and carrying out the analyses of these.

PASSENGER CARS IN THE OUTER THREE FEET OF PAVEMENT - A summary of the results of this analysis appears in Table 14. Figure 21 contains a graphical representation of the percentages at each location for each condition.

Table 13

PERCENTS OF VEHICLES

IN SPECIFIC ZONES OF THE PAVEMENT - US 31

Passenger Cars

Portland Cement Concrete			Bituminous Concrete		
Location	Day	Night	Location	Day	Night
Outer Three Feet of Pavement					
S-1	0	19	S-3	8	4
S-2	6	1	S-4	4	10
N-3	3	1	N-1	1	3
N-4	1	0	N-2	2	9
More Than Five Feet From Pavement Edge					
S-1	42	8	S-3	48	56
S-2	34	54	S-4	45	26
N-3	34	32	N-1	50	76
N-4	72	65	N-2	31	39

Semi-Trailer Trucks

Portland Cement Concrete			Bituminous Concrete		
Location	Day	Night	Location	Day	Night
Outer Two Feet of Pavement					
S-1	4	10	S-3	16	8
S-2	4	2	S-4	12	8
N-3	10	2	N-1	10	2
N-4	2	4	N-2	12	2
More Than Four Feet From Pavement Edge					
S-1	6	6	S-3	10	12
S-2	2	14	S-4	10	6
N-3	16	14	N-1	6	18
N-4	16	22	N-2	4	16

Table 14

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS OF

PASSENGER CARS IN THE OUTER THREE FEET OF PAVEMENT - US 31

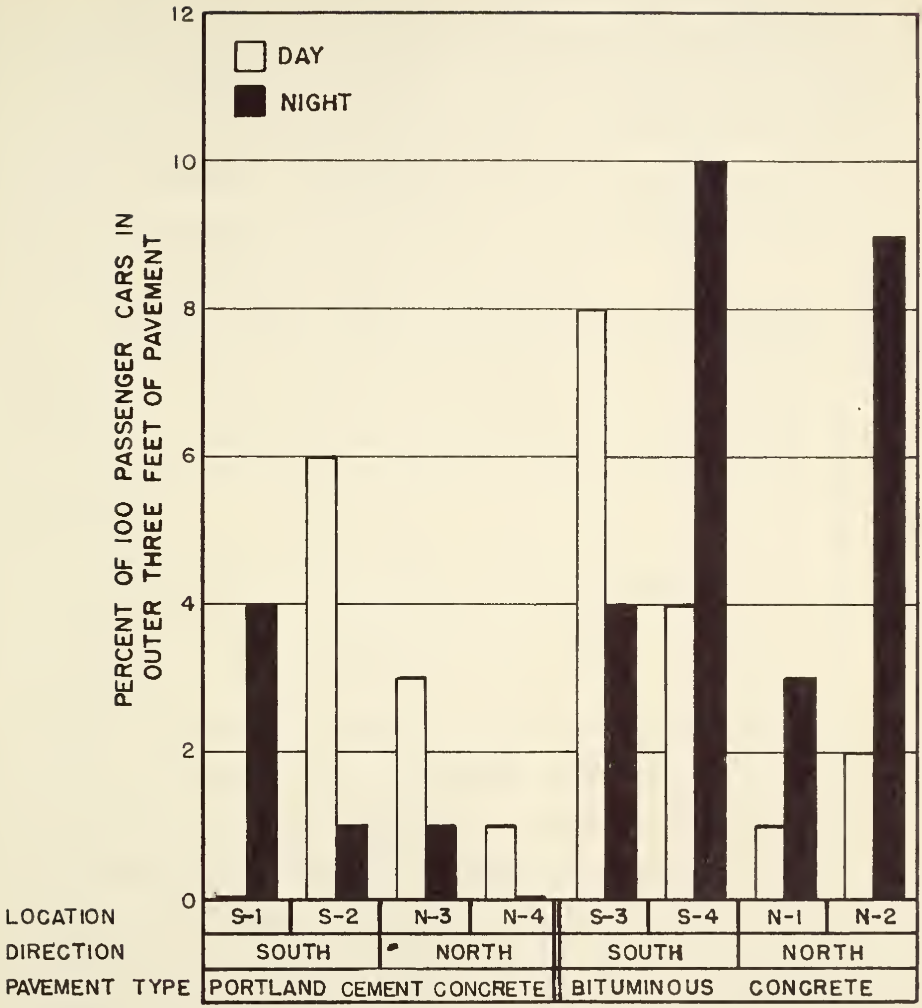
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.052762	.052762	3.021	NS
Direction	1	.127663	.127663	7.309	NS
Period	1	.040280	.040280	2.306	NS
Location in Type by Direction	4	.069866	.017466	--	--
Type by Direction	1	.004482	.004482	1	NS
Type by Period	1	.005048	.005048	1	NS
Direction by Period	1	.007788	.007788	1	NS
Type by Direction by Period	1	.084100	.084100	1	NS
Period by Location in Type by Direction	4	.351712	.087930	--	--

Notes ---

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



PERCENT OF PASSENGER CARS IN OUTER THREE FEET OF PAVEMENT—US 31

FIGURE 21

The results of this analysis shows none of the factors considered nor their accompanying interactions to be significant. By inspection of the table of average percents (Table 15), it can be seen that very little variation exists throughout the table. Generally, the percent was somewhat greater in this zone on the bituminous concrete than on the portland cement concrete, however, this difference was not significant.

PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT EDGE - Table 16 contains a summary of the results of this analysis of variance. Percentages in this zone of the pavement at each location during the day and at night are shown graphically in Figure 22.

The results of this analysis show none of the factors considered to have a significant effect on the percent of passenger cars traveling in this zone. In Table 17, which contains the average percents for this zone of the pavement, it can be seen that the only substantial differences in percents exist between the two directions and also between the two types of pavement at night. The percent of vehicles in this zone was somewhat greater on the bituminous concrete at night than on the portland cement concrete for the same period when directions were not considered. The overall percents, however, for both pavement types vary only slightly from one another. The percent of passenger cars in this zone was the same for both day and night when type of pavement and direction were not considered.

Table 15

AVERAGE PERCENTS - US 31

PASSENGER CARS IN OUTER THREE FEET OF PAVEMENT

Portland Cement Concrete, Day	2.50
Portland Cement Concrete, Night	5.25
Bituminous Concrete, Day	3.75
Bituminous Concrete, Night	6.50
Northbound, Portland Cement Concrete	1.25
Northbound, Bituminous Concrete	3.75
Southbound, Portland Cement Concrete	6.50
Southbound, Bituminous Concrete	6.50
Portland Cement Concrete	3.88
Bituminous Concrete	5.12
Northbound	2.50
Southbound	6.50
Day Observations	3.12
Night Observations	5.87

Table 16

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS OF PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT EDGE - US 31

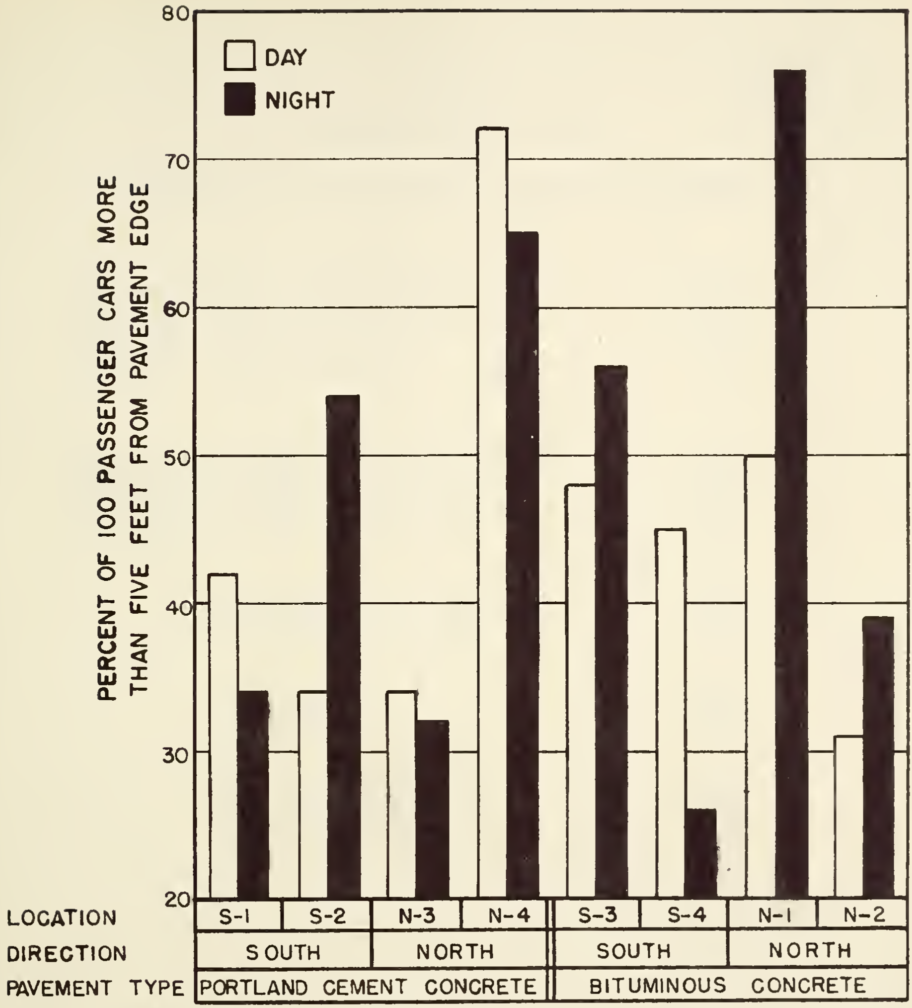
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.035344	.035344	1	NS
Direction	1	.231794	.231794	1	NS
Period	1	.001398	.001398	1	NS
Location in Type by Direction	4	1.188404	.297101	--	--
Type by Direction	1	.064262	.064262	1	NS
Type by Period	1	.075487	.075487	1	NS
Direction by Period	1	.088863	.088863	1	NS
Type by Direction by Period	1	.032202	.032202	1	NS
Period by Location in Type by Direction	4	.503337	.125834	---	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



PERCENT OF PASSENGER CARS MORE THAN FIVE FEET FROM PAVEMENT EDGE–US 31

FIGURE 22

Table 17

AVERAGE PERCENTS - US 31

PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT EDGE

Portland Cement Concrete, Day	45.50
Portland Cement Concrete, Night	39.75
Bituminous Concrete, Day	43.50
Bituminous Concrete, Night	49.25
Northbound, Portland Cement Concrete	50.75
Northbound, Bituminous Concrete	49.00
Southbound, Portland Cement Concrete	34.50
Southbound, Bituminous Concrete	43.75
Portland Cement Concrete	42.63
Bituminous Concrete	46.38
Northbound	49.87
Southbound	39.12
Day Observations	44.50
Night Observations	44.50

SEMI-TRAILER TRUCKS IN THE OUTER TWO FEET OF PAVEMENT - A summary of the results of this analysis is listed in Table 18. Figure 23 contains a graphical representation of the percents at each location for both periods of observation.

The results of this analysis show none of the major factors nor the accompanying interactions to be significant. Table 19 lists the average percents of semi-trailer trucks in this zone of the pavement. By inspection of this table and Figure 23, it can be seen that the percent of these vehicles in this zone is somewhat greater on bituminous concrete than on portland cement concrete. Averaged across all locations for all conditions, however, this difference appears quite small, and hence, non-significant as the results point out.

SEMI TRAILER TRUCKS MORE THAN FOUR FEET FROM THE PAVEMENT EDGE - The results of the analysis on the percents of semi-trailer trucks in this zone of the pavement are summarized in Table 20. A graphical representation of the percents at each location for both periods of observation appears in Figure 24.

These results show direction and the pavement type by direction interaction to be significant factors. These significant effects can be seen more readily by inspection of Figure 24 and the summary of average percents in Table 21. It will be noted that the average percent of semi-trailer trucks in this zone is greater in a northbound direction than in a southbound direction when the other factors are not con-

Table 18

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS OF

SEMI-TRAILER TRUCKS IN THE OUTER TWO FEET OF PAVEMENT - US 31

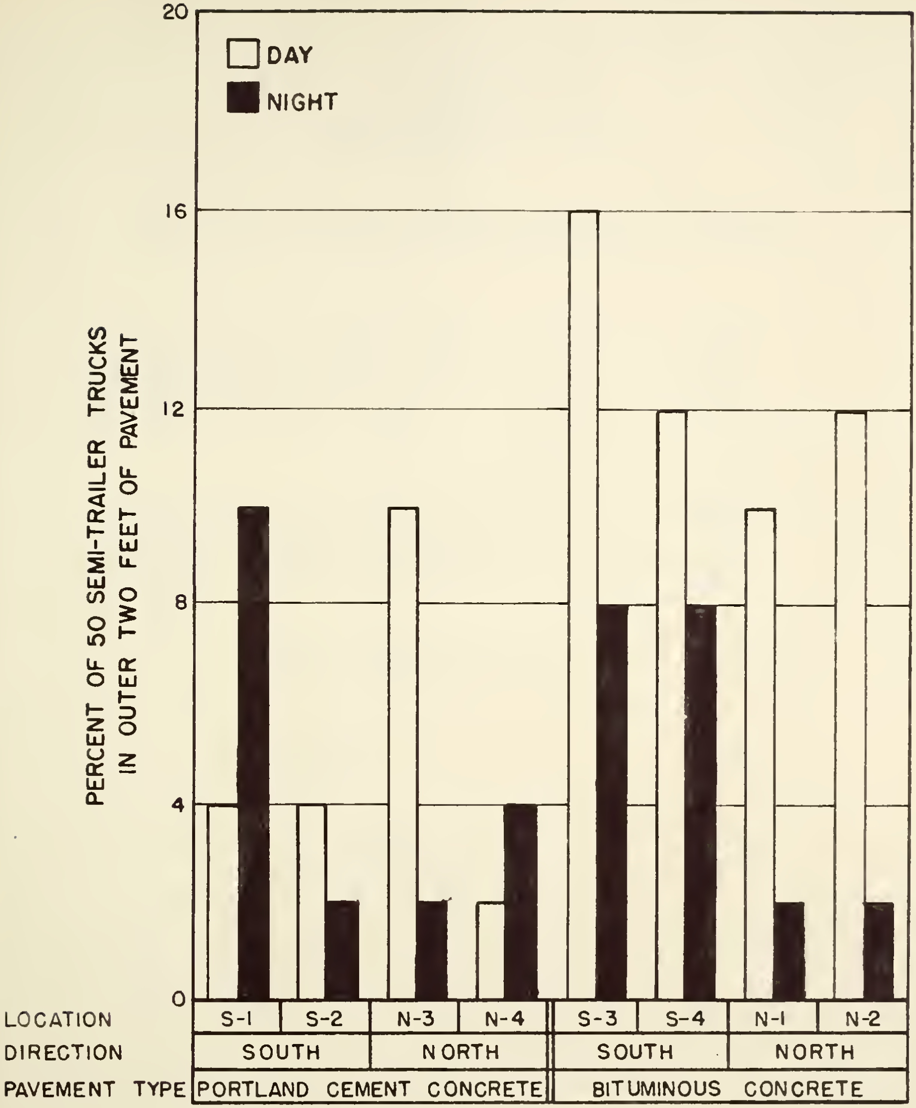
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.097593	.097593	7.624	NS
Direction	1	.048158	.048158	3.762	NS
Period	1	.103330	.103330	4.398	NS
Location in Type by Direction	4	.051201	.012800	--	--
Type by Direction	1	.025600	.025600	2.000	NS
Type by Period	1	.068644	.068644	2.922	NS
Direction by Period	1	.036347	.036347	1.547	NS
Type by Direction by Period	1	.000086	.000086	1	NS
Period by Location in Type by Direction	4	.093969	.023492	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



PERCENT OF SEMI-TRAILER TRUCKS IN OUTER TWO FEET OF PAVEMENT-US 31

FIGURE 23

Table 19

AVERAGE PERCENTS - US 31

SEMI-TRAILER TRUCKS IN THE OUTER TWO FEET OF PAVEMENT

Portland Cement Concrete, Day	4.50
Portland Cement Concrete, Night	5.00
Bituminous Concrete, Day	12.50
Bituminous Concrete, Night	8.50
Northbound, Portland Cement Concrete	4.50
Northbound, Bituminous Concrete	6.50
Southbound, Portland Cement Concrete	5.00
Southbound, Bituminous Concrete	11.00
Portland Cement Concrete	4.75
Bituminous Concrete	8.75
Northbound	5.50
Southbound	8.00
Day Observations	8.50
Night Observations	6.75

Table 20

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS OF SEMI-TRAILER TRUCKS MORE THAN FOUR FEET FROM THE PAVEMENT EDGE - US 31

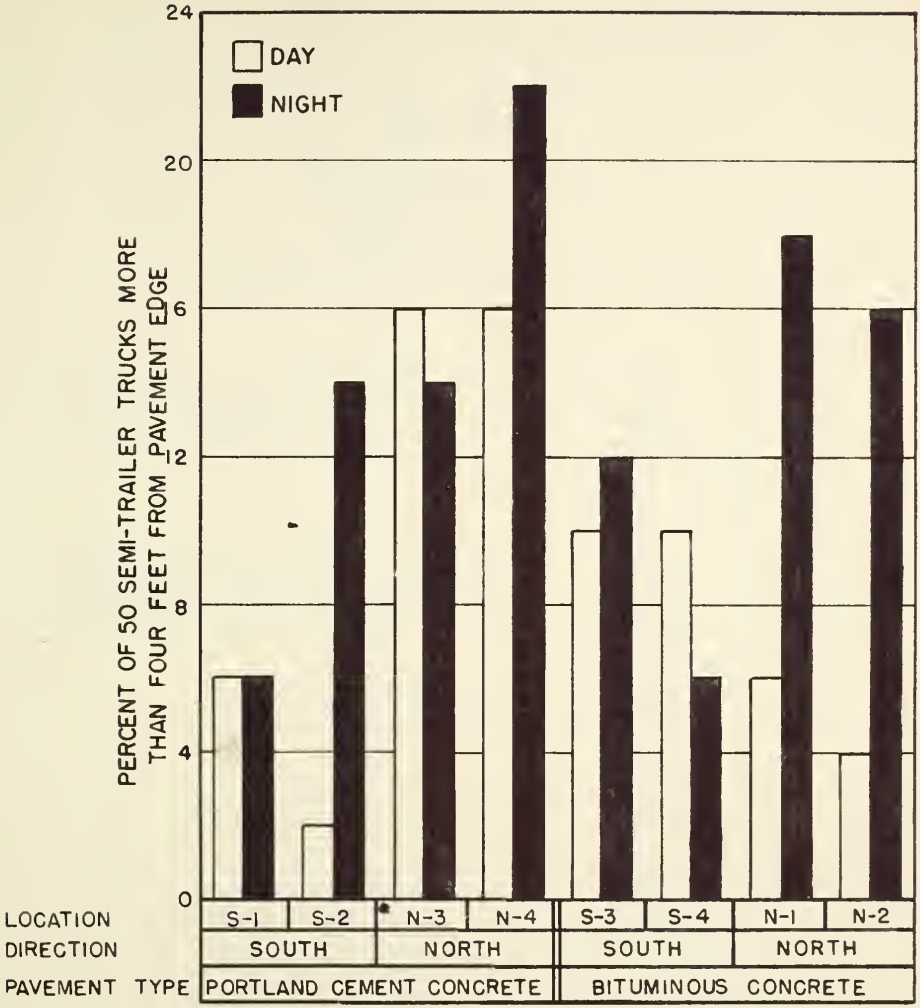
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Type	1	.007383	.007383	1.037	NS
Direction	1	.132551	.132551	18.614	*
Period	1	.105251	.105251	5.197	NS
Location in Type by Direction	4	.028484	.007121	--	--
Type by Direction	1	.096301	.096301	13.523	*
Type by Period	1	.001164	.001164	1	NS
Direction by Period	1	.015656	.015656	1	NS
Type by Direction by Period	1	.101139	.101139	4.994	NS
Period by Location in Type by Direction	4	.081011	.020253	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Differense.



PERCENT OF SEMI-TRAILER TRUCKS MORE THAN FOUR FEET FROM PAVEMENT EDGE-US 31

FIGURE 24

Table 21

AVERAGE PERCENTS – US 31

SEMI-TRAILER TRUCKS

MORE THAN FOUR FEET FROM THE PAVEMENT EDGE

Portland Cement Concrete, Day	10.00
Portland Cement Concrete, Night	14.00
Bituminous Concrete, Day	7.50
Bituminous Concrete, Night	13.00
Northbound, Portland Cement Concrete	17.00
Northbound, Bituminous Concrete	11.00
Southbound, Portland Cement Concrete	7.00
Southbound, Bituminous Concrete	9.50
Portland Cement Concrete	12.00
Bituminous Concrete	10.25
Northbound	14.00
Southbound	8.25
Day Observations	8.75
Night Observations	13.50

sidered. Also, the percent in this zone on the portland cement concrete, northbound, is larger than that for the same pavement in a southbound direction. When the two pavement types are considered in the northbound direction only, it is found that the percent in this zone on the portland cement concrete is considerably larger than on the bituminous concrete. In the analysis of variance on the logarithms of the variances for semi-trailer trucks (Table 11), this same pavement type by direction interaction was found significant.

INVESTIGATION OF WIND VELOCITY AND DIRECTION

In the procedure, it was stated that recordings of wind velocity and direction were taken at each location while the data on lateral placement were being collected. These readings were taken at each fifteen minute interval during the period of observation and also when any abrupt changes in velocity or direction were observed.

For the sake of tabulation and discussion, these recordings were averaged for the period of observation at each location. In so doing, the mean velocity and the prevailing direction of the wind were determined. Table 22 lists these data for each location during each period of observation, and also, the angle between the direction of wind and movement and a vector diagram of this relation. It will be noted in this table, that at no time was data collected when the wind conditions did not satisfy the criteria established to determine whether these con-

Table 22

STATION	PERIOD	ROAD BEARING AT STATION	MEAN VELOCITY OF WIND (MPH)	PREVAILING DIRECTION OF WIND	DIRECTION OF WIND & TRAVEL	VECTOR DIAGRAM
S-1 Day	August 9, 1957 4:00-4:30(C), 6:20(T)	S 1° E	1.25	S 48° W	49° Right	
S-1 Night	August 9, 1957 8:25-9:00(C), 9:40(T)	S 1° E	0.00	--	--	
S-2 Day	August 5, 1957 2:55-4:00(C), 4:57(T)	S 1° E	5.56	N 11° E	168° Left	
S-2 Night	August 5, 1957 8:35-10:00(C), 10:50T)	S 1° E	0.00	--	--	
S-3 Day	August 23, 1957 3:00-3:35(C), 5:05(T)	S 10° E	2.83	S 68° W	78° Right	
S-3 Night	August 23, 1957 8:00-8:25(C), 10:10(T)	S 10° E	0.00	--	--	
S-4 Day	August 6, 1957 2:00-2:40(C), 3:20(T)	S 12° E	1.50	N 25° E	143° Left	
S-4 Night	August 6, 1957 8:30-9:40(C), 9:55(T)	S 12° E	0.00	--	--	
N-1 Day	August 7, 1957 4:35-5:00(C), 6:15(T)	N 20° W	1.31	S 23° W	137° Left	
N-1 Night	August 7, 1957 9:00-10:00(C), 10:10T)	N 20° W	0.00	--	--	
N-2 Day	August 3, 1957 11:20-11:45(C), 2:35(T)	N 21° W	3.64	S 47° W	112° Left	
N-2 Night	August 2, 1957 8:35-9:15(C), 10:20(T)	N 21° W	0.00	--	--	
N-3 Day	August 8, 1957 3:15-3:50(C), 4:55(T)	N 2° W	0.71	N 79° W	77° Left	
N-3 Night	August 8, 1957 8:25-9:25(C), 9:40(T)	N 2° W	0.00	--	--	
N-4 Day	August 1, 1957 3:15-5:00(C), 5:15(T)	N 28° W	1.50	S 45° W	107° Left	
N-4 Night	August 1, 1957 8:45-9:45(T), 10:00(C)	N 28° W	0.00	--	--	

ditions were suitable for collection of lateral placement data. In some cases, the wind was striking the vehicles at an angle between 45° and 135° to the direction of movement, however, the velocity was not critical in these cases. At night, for all locations, the wind was calm. This is usually the case in this weather zone during the month of August when all the observations were made.

By consideration of this wind data and the fact that the lateral placement data were collected during a summer month only under dry conditions, it can be said that the data for this study was collected under the most favorable weather conditions attainable.

EFFECT OF PAVEMENT EDGE LINES

GENERAL REMARKS

In this portion of the study, an investigation was made to determine if there were any effects on the lateral placement of vehicles after the placement of edge lines on the pavement. Other factors which were investigated were pavement width and period of observation. Observations were made before and after the placement of the edge lines on highways 20', 22', and 24' wide during the day and at night. Passenger cars were studied on all pavement widths, however, semi-trailer trucks were studied on the 24' pavement only. The lack of commercial traffic of this type on the 20' and 22' pavements made it difficult to make observations on such vehicles.

When the field sampling had been completed, the data were compiled into the form of frequency distributions as shown in Tables 23 and 24. A graphical representation of these distributions in the form of frequency polygons is shown in Figure 25. A summary of the statistical data obtained from these distributions for purposes of analysis is listed in Tables 25 and 26. This data consists of the mean which is the arithmetic mean of the measured variable, the variance which is a measure of the dispersion of the individual observations, and the standard deviation which is another measure of variation and is equal to the square root of the variance.

Again, the data had to be tested by a Bartlett test to

Table 23

DISTRIBUTION OF LATERAL PLACEMENTS

IN ONE-FOOT SECTIONS FROM OUTER EDGE

OF PAVEMENT TO RIGHT WHEEL OF VEHICLE - SR 43 & US 24

-Passenger Cars-

Location & Condition		One-Foot Sections From Outer Edge of Pavement 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Total
	B-D	2	10	37	36	13	2	-	-	-	100
	B-N	-	14	32	28	21	4	1	-	-	100
20-1	A-D	2	5	38	42	11	2	-	-	-	100
	A-N	-	9	21	42	22	6	-	-	-	100
	B-D	-	2	15	42	31	8	2	-	-	100
	B-N	-	4	18	45	26	7	-	-	-	100
20-2	A-D	-	3	12	39	38	8	-	-	-	100
	A-N	-	6	22	46	23	3	-	-	-	100
	B-D	-	2	19	45	29	5	-	-	-	100
	B-N	-	-	25	38	25	9	3	-	-	100
22-1	A-D	-	-	22	44	30	4	-	-	-	100
	A-N	-	1	14	37	35	12	1	-	-	100
	B-D	-	-	25	39	32	4	-	-	-	100
	B-N	-	-	15	29	46	10	-	-	-	100
22-2	A-D	-	-	19	42	38	1	-	-	-	100
	A-N	-	2	18	41	32	6	1	-	-	100
	B-D	-	1	6	29	33	19	7	-	-	100
	B-N	-	1	1	25	32	31	10	-	-	100
24-1	A-D	-	-	7	12	29	35	16	1	-	100
	A-N	-	-	8	13	28	35	15	1	-	100
	B-D	-	2	22	32	29	11	4	-	-	100
	B-N	-	1	10	26	36	16	11	-	-	100
24-2	A-D	-	3	27	38	21	9	2	-	-	100
	A-N	-	3	12	37	29	16	3	-	-	100

Notes:

B-D - Day Observation, Before Edge Lines
B-N - Night Observations, Before Edge Lines
A-D - Day Observations, After Edge Lines
A-N - Night Observations, After Edge Lines

Table 24

DISTRIBUTION OF LATERAL PLACEMENTS

IN ONE FOOT SECTIONS FROM OUTER EDGE

OF PAVEMENT TO RIGHT WHEEL OF VEHICLE - US 24

-Semi Trailer Trucks-

Location and Condition		One-Foot Sections From Outer Edge Of Pavement 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	Total
	B-D	-	2	16	29	3	-	-	-	50
	B-N	-	15	-	14	7	3	1	-	40
24-1	A-D	-	2	12	18	12	3	3	-	50
	A-N	-	-	8	14	12	6	-	-	40
	B-D	2	10	23	13	2	-	-	-	50
	B-N	-	6	18	13	3	-	-	-	40
24-2	A-D	1	13	26	8	2	-	-	-	50
	A-N	-	4	18	14	4	-	-	-	40

Notes:

B-D - Day Observations, Before Edge Lines
B-N - Night Observations, Before Edge Lines
A-D - Day Observations, After Edge Lines
A-N - Night Observations, After Edge Lines

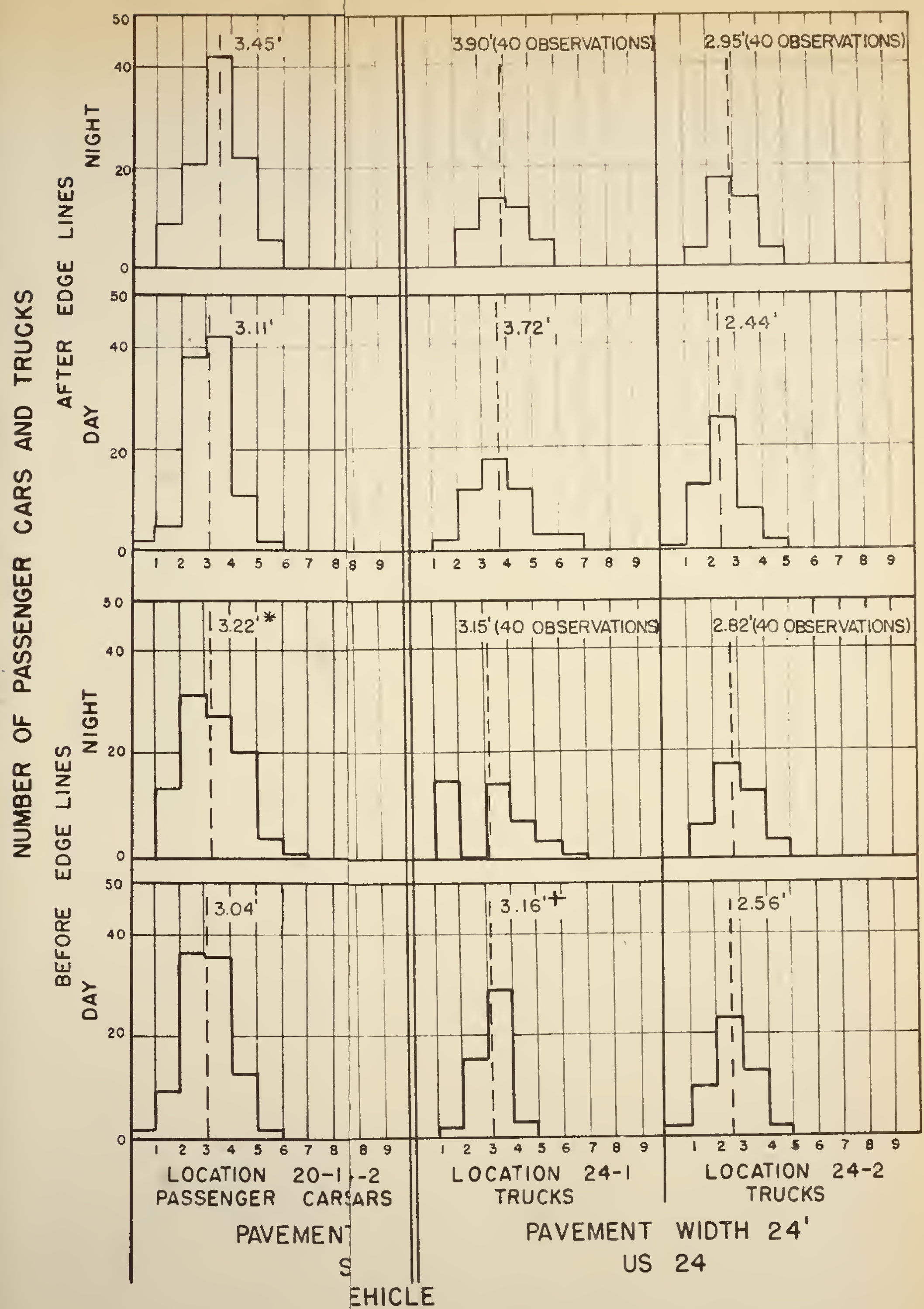
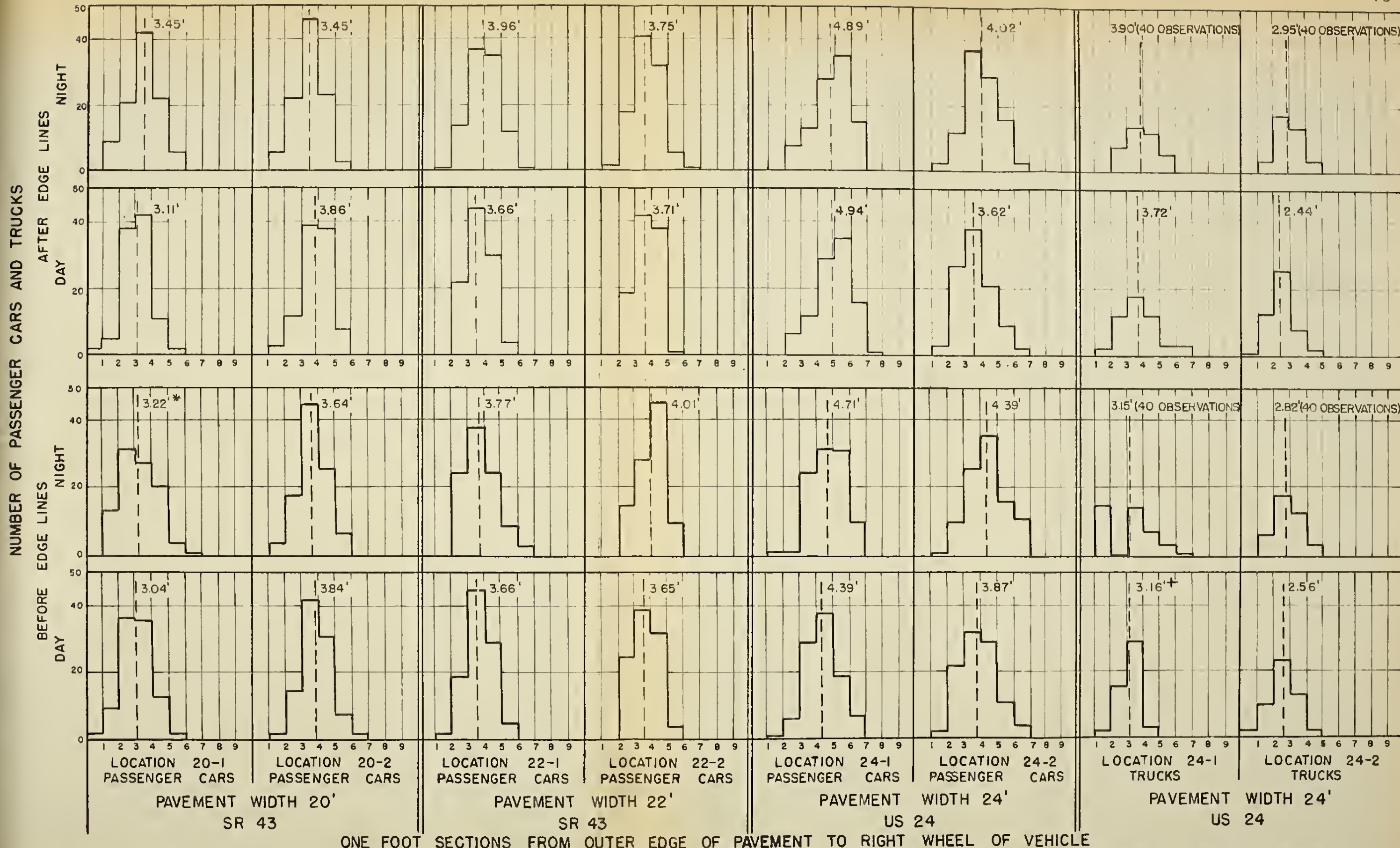


FIGURE 25

*MEAN LATERAL PLACEMENT- 100 OBSERVATIONS
+MEAN LATERAL PLACEMENT- 50 OBSERVATIONS
UNLESS INDICATED OTHERWISE



*MEAN LATERAL PLACEMENT-100 OBSERVATIONS
+MEAN LATERAL PLACEMENT- 50 OBSERVATIONS
UNLESS INDICATED OTHERWISE

FIGURE 25 FREQUENCY POLYGONS, PASSENGER CARS AND TRUCKS- SR 43 & US 24

Table 25

SUMMARY OF STATISTICAL DATA - SR 43 AND US 24

-Passenger Cars-

Location and Condition		Mean	Variance	Standard Deviation
	B-D	3.04	0.9580	0.9788
	B-N	3.22	1.2743	1.1288
20-1	A-D	3.11	0.8060	0.8978
	A-N	3.45	1.0379	1.0187
	B-D	3.84	0.9337	0.9663
	B-N	3.64	0.8691	0.9323
20-2	A-D	3.86	0.8186	0.9050
	A-N	3.45	0.8157	0.9031
	B-D	3.66	0.7418	0.8613
	B-N	3.77	1.0678	1.0333
22-1	A-D	3.66	0.8186	0.9050
	A-N	3.96	0.8974	0.9473
	B-D	3.65	0.7146	0.8453
	B-N	4.01	0.7575	0.8703
22-2	A-D	3.71	0.5716	0.7560
	A-N	3.75	0.8561	0.9253
	B-D	4.39	1.0888	1.0435
	B-N	4.71	1.0565	1.0380
24-1	A-D	4.94	1.2994	1.1400
	A-N	4.89	1.3514	1.1625
	B-D	3.87	1.2658	1.1251
	B-N	4.39	1.3514	1.1625
24-2	A-D	3.62	1.1370	1.0663
	A-N	4.02	1.1814	1.0869

Notes - - -

B-D - Day Observations, Before Edge Lines
B-N - Night Observations, Before Edge Lines
A-D - Day Observations, After Edge Lines
A-N - Night Observations, After Edge Lines

Table 26

SUMMARY OF STATISTICAL DATA - US 24

-Semi-Trailer Trucks-

Location and Condition		Mean	Variance	Standard Deviation
	B-D	3.16	0.4331	0.6581
	B-N	3.15	2.1308	1.4597
24-1	A-D	3.72	1.3996	1.1830
	A-N	3.90	0.9641	0.9820
	B-D	2.56	0.7922	0.8901
	B-N	2.82	0.6865	0.8285
24-2	A-D	2.44	0.6698	0.8184
	A-N	2.95	0.6641	0.8149

Notes - - -

B-D - Day Observations, Before Edge Lines
B-N - Night Observations, Before Edge Lines
A-D - Day Observations, After Edge Lines
A-N - Night Observations, After Edge Lines

determine whether the homogeneity of variance and normality assumptions could be made. It was found that the data lacked homogeneity, and hence, the variances had to be transformed into their logarithms to restore the homogeneity necessary for proper analysis.

When the data had been transformed and tabulated for analysis, analyses of variance were made on the mean lateral placements, the logarithms of the variances, and the percents of vehicles in specific zones of the pavement.

For passenger cars, these analyses were made according to the following model:

$$Y_{ijkl} = \mu + W_i + L_{j(i)} + E_k + WE_{(ik)} + LE_{kj(i)} + P_l + WP_{il} + PL_{lj(i)} + EP_{kl} + WEP_{ikl} + LEP_{lkj(i)}.$$

Where:

μ = Overall Average Effect.	
W = Pavement Width	i = 1,2,3
L = Locations	j = 1,2
E = Edgelines (Before-After)	k = 1,2
P = Period of Observation	l = 1,2

Similarly, for semi-trailer trucks, the statistical analyses were performed according to the following model:

$$Y_{ikj} = \mu + E_i + L_{j(i)} + P_k + EP_{ik} + LP_{kj(i)}.$$

Where:

μ = Overall Average Effect.	
E = Edgeline (Before-After)	i = 1,2
L = Locations	j = 1,2
P = Period of Observation	k = 1,2

COMPARISON OF MEAN LATERAL PLACEMENTS

As was stated in the preceding section, in an analysis of variance of the mean lateral placements, if significant differences are found among any of the factors investigated, further analysis is carried out. If, however, no significant differences are found, further analysis is deemed unnecessary.

PASSENGER CARS - A summary of the results of the analysis of variance of mean lateral placements for passenger cars appears in Table 27. A graphical representation of the means for each location, before and after edge lines, during the day and at night appears in Figure 26.

The results of this analysis show none of the major factors investigated to be significant. However, the edge line by location in pavement width interaction and the period by location in pavement width interaction both appeared significant. This can be seen more readily by examination of the table of average means (Table 28) and the graphical representations of the interactions in Figure 27. If these interactions were not significant, the graphs of the average means in Figure 27 would form approximately parallel lines in both cases. In Figure 27a, it will be noted that at all locations except location 20-2, the night mean was greater than the day mean. Also, between locations, a comparable pattern is observed in day and night observations except between locations 20-1, 20-2, and 22-1. Figure 27b shows the edge line by location in pavement width interaction. It will be noted that the mean

Table 27

SUMMARY OF THE ANALYSIS OF VARIANCE ON

MEAN LATERAL PLACEMENTS - SR 43 AND US 24

-Passenger Cars-

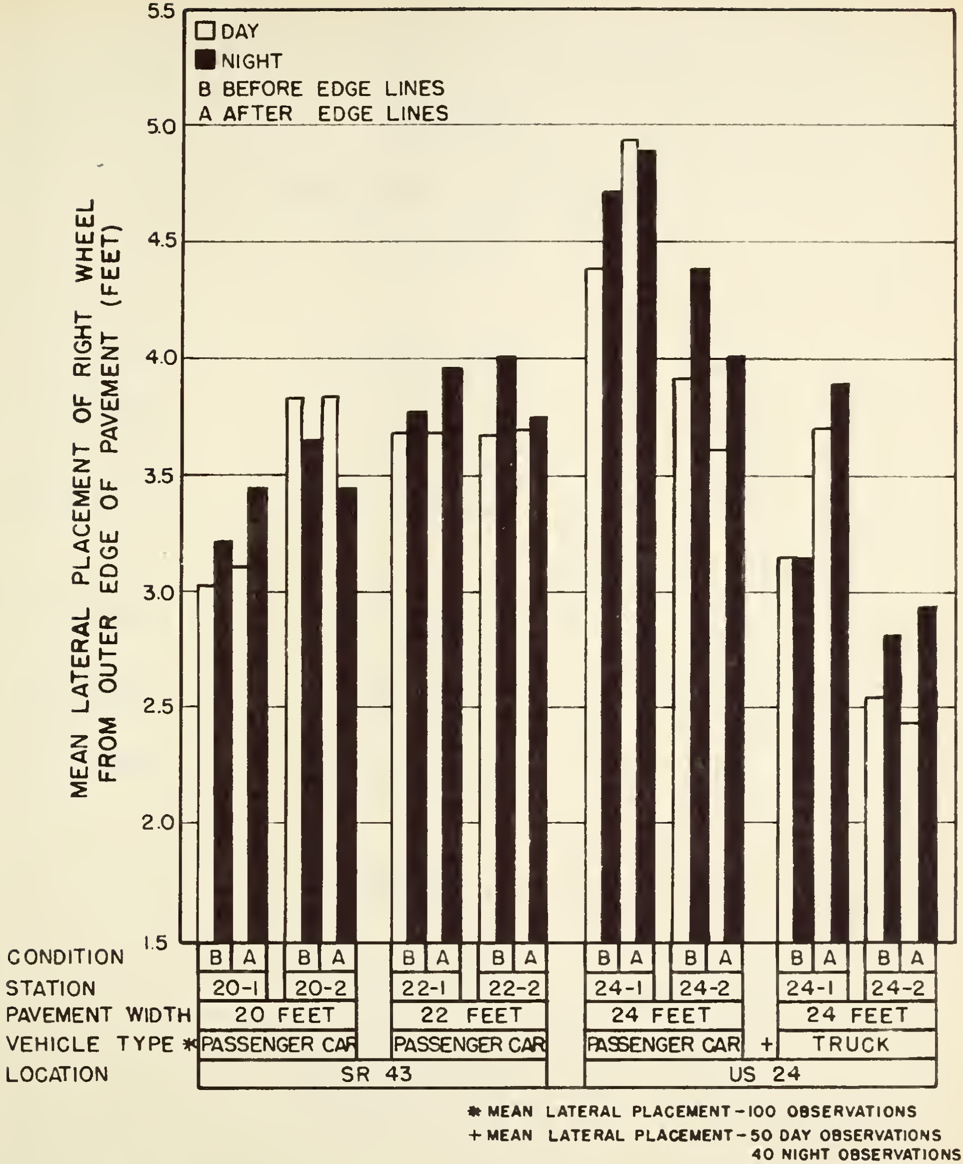
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Width	2	3.31823	1.65912	3.045	NS
Locations in Pavement Width	3	1.63484	.54495	--	--
Edge Lines	1	.00770	.00770	1	NS
Pavement Width by Edge Lines	2	.00043	.00022	1	NS
Locations by Edge Lines in Pavement Width	3	.29894	.09965	10.098	*
Period	1	.12184	.12184	1.685	NS
Pavement Width by Period	2	.10270	.05135	1	NS
Period by Locations in Pavement Width	3	.21694	.07231	7.328	*
Edge Lines by Period	1	.03154	.03154	3.196	NS
Residual	5	.04934	.00987	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



MEAN LATERAL PLACEMENT, PASSENGER CARS AND TRUCKS—SR 43 & US 24

FIGURE 26

Table 28

AVERAGE MEANS - SR 43 AND US 24

-Passenger Cars-

20' Pavement	Before Edge Lines	3.44'
	After Edge Lines	3.47'
22' Pavement	Before Edge Lines	3.77'
	After Edge Lines	3.82'
24' Pavement	Before Edge Lines	4.34'
	After Edge Lines	4.37'
20' Pavement	Day Observations	3.47'
	Night Observations	3.44'
22' Pavement	Day Observations	3.72'
	Night Observations	3.88'
24' Pavement	Day Observations	4.21'
	Night Observations	4.50'
	20' Pavement	3.45'
	22' Pavement	3.80'
	24' Pavement	4.35'
	Before Edge Lines	3.85'
	After Edge Lines	3.89'
	Day Observations	3.80'
	Night Observations	3.94'

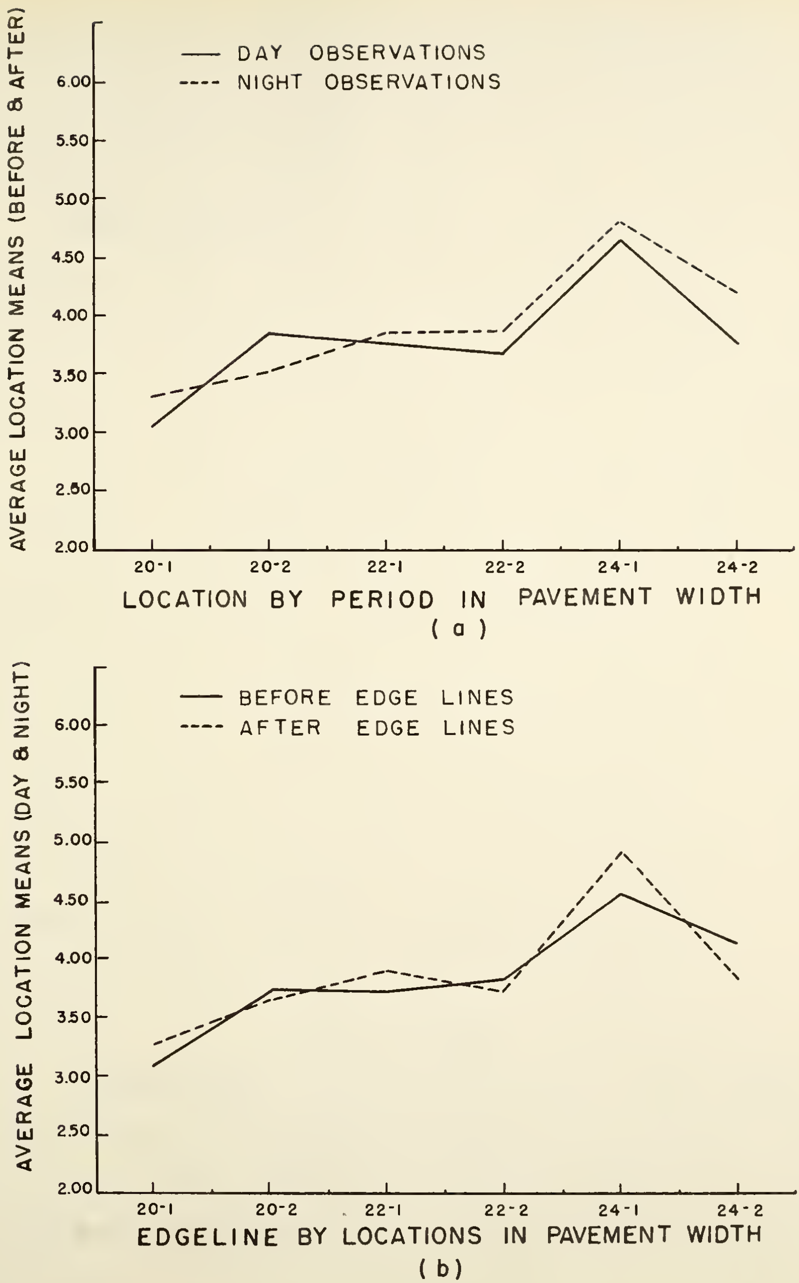

DAY OBSERVATIONS
NIGHT OBSERVATIONS
AVERAGE LOCATION MEANS (BEFORE & AFTER)
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
20-1
20-2
22-1
22-2
24-1
24-2
LOCATION BY PERIOD IN PAVEMENT WIDTH
(a)
BEFORE EDGE LINES
AFTER EDGE LINES
AVERAGE LOCATION MEANS (DAY & NIGHT)
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
20-1
20-2
22-1
22-2
24-1
24-2
EDGELINE BY LOCATIONS IN PAVEMENT WIDTH
(b)

FIGURE 27

after edge lines was farther from the edge at locations 20-1, 22-1, and 24-1, than the mean before edge lines. Whereas, the mean after edge lines was closer to the edge than the mean before edge lines at locations 20-2, 22-2, and 24-2.

SEMI-TRAILER TRUCKS - A summary of the results of the analysis of variance on the mean lateral placement of semi-trailer trucks appears in Table 29. A graphical representation of the means at each location, day and night, both before and after edge lines is shown in Figure 26.

The results of this analysis show none of the factors to be significant. Any highly significant effect of edge lines on the lateral placement of semi-trailer trucks would have shown up in this analysis. It must be remembered, however, that the analysis was modified by the fact that observations were made only on the pavement width. Nevertheless, the results are consistent with the more extensive analysis performed on passenger cars. This fact is substantiated by examination of the table of average means for semi-trailer trucks (Table 30). The pattern observed in these means is consistent with the pattern of means for passenger cars.

STUDY OF VARIANCES

PASSENGER CARS - The summary of the results of the analysis of variance on the logarithms of the variances for passenger cars is shown in Table 31. The location variances for before and after edge lines at each location both during the

Table 29

SUMMARY OF THE ANALYSIS OF VARIANCE ON

MEAN LATERAL PLACEMENTS - US 24

-Semi-Trailer Trucks-

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Edge Lines	1	.2178	.2178	1	NS
Location in Edge Lines	2	1.2482	.6241	-	--
Period	1	.1104	.1104	1	NS
Edge Lines in Period	1	.0242	.0242	1	NS
Period by Location in Edge Line	2	.2567	.1284	-	--

Note. - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.

Table 30

AVERAGE MEANS - US 24

-Semi-Trailer Trucks-

Before Edge Lines, Day	2.86'
Before Edge Lines, Night	2.99'
After Edge Lines, Day	3.08'
After Edge Lines, Night	3.42'
Before Edge Lines	2.92'
After Edge Lines	3.25'
Day Observations	2.97'
Night Observations	3.21'

Table 31

SUMMARY OF THE ANALYSIS OF VARIANCE ON

THE LOGARITHMS OF THE VARIANCES - SR 43 & US 24

-Passenger Cars-

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Width	2	.139499	.069750	8.553	NS
Locations in Pavement Width	3	.024465	.008155	--	--
Edge Lines	1	.002535	.002535	1	NS
Pavement Width by Edge Lines	2	.006711	.003355	1	NS
Location by Edge Lines in Pavement Width	3	.011222	.003741	1.972	NS
Period	1	.017545	.017545	5.795	NS
Pavement Width by Period	2	.007694	.003847	1.271	NS
Period by Locations in Pavement Width	3	.009083	.003028	1.596	NS
Edge Lines by Period	1	.000180	.000180	1	NS
Residual	5	.009483	.001897	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

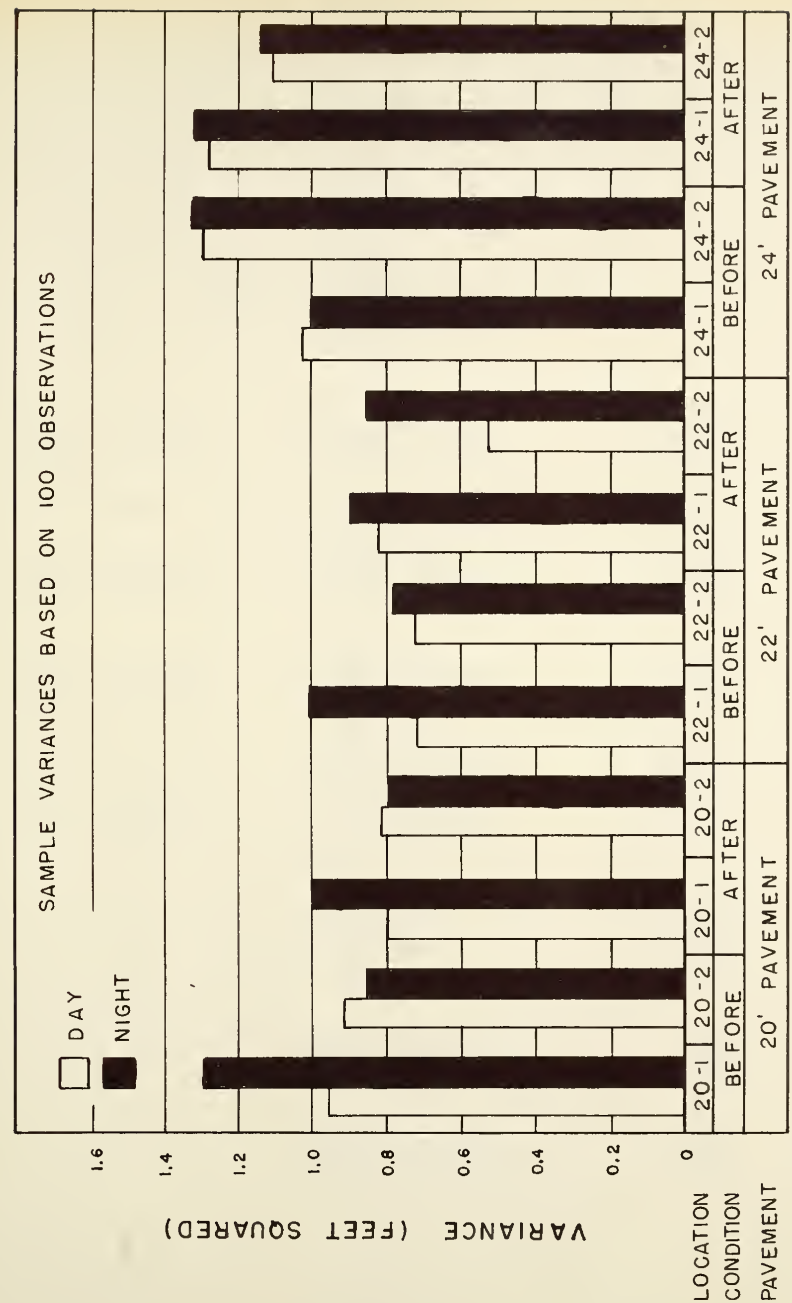
NS Failure To Reject The Hypothesis Of No Population Difference.

day and at night are represented graphically in Figure 28.

The results of the analysis of variance shows that none of the major factors considered nor their accompanying interactions are significant. It will be noted, however, that in the table of average variances (Table 32), the variance is decreased after the placement of edge lines in all but one instance. Also on all pavement widths, the variance was greater at night than during the day both before and after the edge lines were placed. None of the differences were great enough, however, to be significant as the analysis of variance shows.

SEMI-TRAILER TRUCKS - Table 33 lists a summary of the results of the analysis of variance on the logarithms of the variances for semi-trailer trucks. A graphical representation of the location variances, before and after edge lines, for both day and night is shown in Figure 29.

These results also show that there are no significant effects on the variances by the factors considered or their accompanying interactions. In the summary of average variances listed in Table 34, however, a similar trend in variances for before and after conditions and between day and night observations can be seen for semi-trailer trucks as was noted for passenger cars. The overall variance for night observations is greater than that for day observations, and the overall after variance shows a slight decrease from the overall before variance. Again, however, these differences were not found to be significant.



LOCATION VARIANCES
PASSENGER CARS - SR 43 & US 24

FIGURE 28

Table 32

AVERAGE VARIANCES - SR 43 AND US 24

-Passenger Cars-

20'	Pavement	Before Edge Lines	1.0088
		After Edge Lines	0.8696
22'	Pavement	Before Edge Lines	0.8204
		After Edge Lines	0.7859
24'	Pavement	Before Edge Lines	1.1906
		After Edge Lines	1.2423
20'	Pavement	Day Observations	0.8791
		Night Observations	0.9993
22'	Pavement	Day Observations	0.7116
		Night Observations	0.8947
24'	Pavement	Day Observations	1.1978
		Night Observations	1.2352
		20' Pavement	0.9392
		22' Pavement	0.8032
		24' Pavement	1.2165
		Before Edge Lines	1.0066
		After Edge Lines	0.9659
		Day Observations	0.9295
		Night Observations	1.0431

Table 33

SUMMARY OF THE ANALYSIS OF VARIANCE ON

THE LOGARITHMS OF THE VARIANCES - US 24

-Semi-Trailer Trucks-

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Edge Lines	1	.000755	.000755	1	NS
Location in Edge Lines	2	.063297	.031650	--	--
Period	1	.026931	.026931	1	NS
Edge Lines by Period	1	.079075	.079075	1.011	NS
Period by Location in Edge Line	2	.156391	.078196	--	--

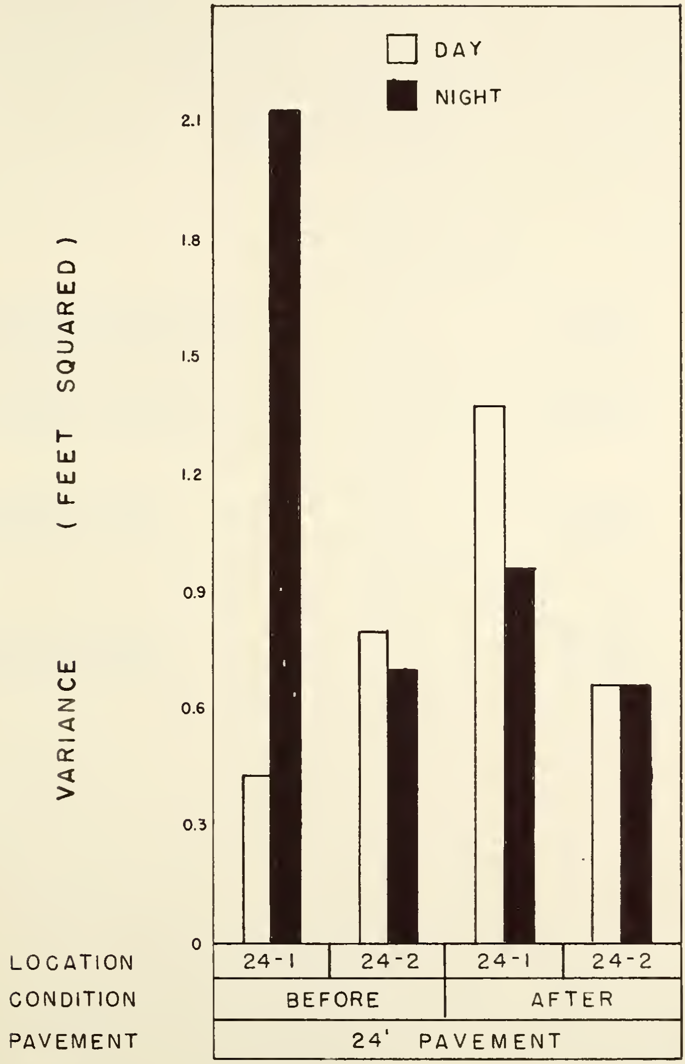
Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.

SAMPLE VARIANCES BASED ON 50 OBSERVATIONS - DAY
SAMPLE VARIANCES BASED ON 40 OBSERVATIONS - NIGHT



LOCATION VARIANCES
TRUCKS - US 24

FIGURE 29

Table 34

AVERAGE VARIANCES - US 24

-Semi-Trailer Trucks-

Before Edge Lines, Day	0.6127
Before Edge Lines, Night	1.4087
After Edge Lines, Day	1.0347
After Edge Lines, Night	0.8141
Before Edge Lines	1.0106
After Edge Lines	0.9244
Day Observations	0.8237
Night Observations	1.1114

STUDY OF VEHICLES IN SPECIFIC ZONES OF THE PAVEMENT

In this portion of the study, the percents of passenger cars in the outer two feet of pavement and more than five feet from the pavement edge were analyzed. Again, in order to restore the homogeneity necessary for the analyses, the percents were transformed into arc-sine values and the analysis performed on these. Table 35 lists the percents in each zone of the pavement at each location before and after edge lines for both periods of observation.

PASSENGER CAR IN THE OUTER TWO FEET OF PAVEMENT - Table 36 contains a summary of the results of the analysis of variance on the percents of passenger cars in this zone of the pavement. These percents are represented graphically in Figure 30 at each location before and after edge lines for both periods of observation.

The results of this analysis show none of the factors investigated to be significant. The average percents listed in Table 37 give an indication of why none of the factors investigated in the analysis were significant. The variation in the percents when averaged across all locations for the two conditions and periods of observation are very small. The percents in this zone on the 20' pavement under all circumstances are somewhat higher than on the other pavement widths. This, of course, is understandable because of the narrowness of the pavement. This difference, however, was not significant in

Table 35

PERCENTS OF PASSENGER CARS

IN SPECIFIC ZONES OF THE PAVEMENT - SR 43 AND US 24

Outer Two Feet of Pavement

Location	Before Edge Lines Day	Before Edge Lines Night	After Edge Lines Day	After Edge Lines Night
20-1	12	14	7	4
20-2	2	4	3	6
22-1	2	0	0	1
22-2	0	0	0	2
24-1	1	1	0	0
24-2	2	1	3	3

More Than Five Feet From the Pavement Edge

Location	Before Edge Lines Day	Before Edge Lines Night	After Edge Lines Day	After Edge Lines Night
20-1	2	5	2	8
20-2	10	7	8	3
22-1	5	12	4	13
22-2	4	10	1	7
24-1	26	41	52	51
24-2	15	27	11	19

Table 36

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS OF PASSENGER CARS IN THE OUTER TWO FEET OF PAVEMENT - SR 43 & US 24

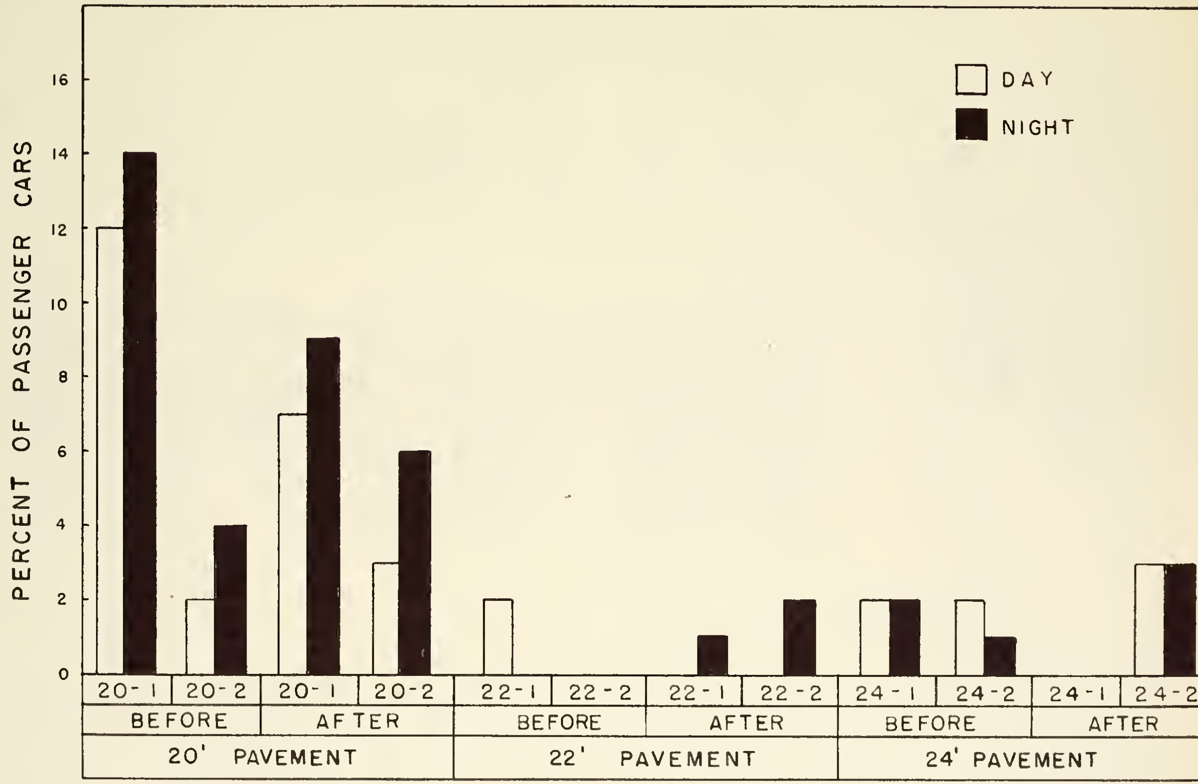
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Width	2	.504249	.252124	5.368	NS
Locations in Pavement Width	3	.140902	.046967	--	--
Edge Lines	1	.002995	.002995	1	NS
Pavement Width by Edge Lines	2	.016309	.008154	1	NS
Locations by Edge Lines in Pavement Width	3	.090365	.030122	4.472	NS
Period	1	.001828	.001828	1	NS
Pavement Width by Period	2	.004933	.002466	1	NS
Period by Locations in Pavement Width	3	.24186	.008062	1.197	NS
Edge Lines by Period	1	.006276	.006276	1	NS
Residual	5	.033679	.006736	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



PERCENT OF PASSENGER CARS IN THE OUTER TWO FEET OF PAVEMENT - SR 43 & US 24

FIGURE 30

Table 37

AVERAGE PERCENTS - SR 43 AND US 24

PASSENGER CARS IN THE OUTER TWO FEET OF PAVEMENT

20' Pavement	Before Edge Lines	8.00
	After Edge Lines	5.00
22' Pavement	Before Edge Lines	0.50
	After Edge Lines	0.75
24' Pavement	Before Edge Lines	1.25
	After Edge Lines	1.50
20' Pavement	Day Observations	6.00
	Night Observations	7.00
22' Pavement	Day Observations	0.50
	Night Observations	0.75
24' Pavement	Day Observations	1.50
	Night Observations	1.25
	20' Pavement	6.50
	22' Pavement	0.63
	24' Pavement	1.38
	Before Edge Lines	3.25
	After Edge Lines	2.42
	Day Observations	2.66
	Night Observations	3.00

the overall analysis.

PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT EDGE - A summary of the results of the analysis of variance on the percents of passenger cars in this zone of the pavement appears in Table 38. A graphical representation of these percents appears in Figure 31.

The results of this analysis show none of the factors considered to be significant. However, the location by edge line in pavement width interaction was significant. This interaction effect also appeared significant in the analysis of variance of the mean lateral placements of passenger cars (See Table 27 and Figure 27). In Figure 32 a graphical representation of this interaction for this analysis is shown. In comparison of Figure 27b and Figure 32, it will be noted that the pattern of the interaction graphically is approximately the same in both cases. Again, in this analysis, the percent of vehicles in this zone of the pavement was greater at locations 20-1 and 24-1 after the placement of the edge lines than before. At locations 20-2, 22-2, and 24-2, however, the presence of edge lines not only decreased the mean lateral placement during the day and night, but also decreased the percent of vehicles traveling more than five feet from the pavement edge during both periods.

In the table of average percents (Table 39) for this zone of the pavement, the percent of passenger cars traveling more than five feet from the edge in considerably higher

Table 38

SUMMARY OF THE ANALYSIS OF VARIANCE ON THE PERCENTS

OF PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT

EDGE - SR 43 & US 24

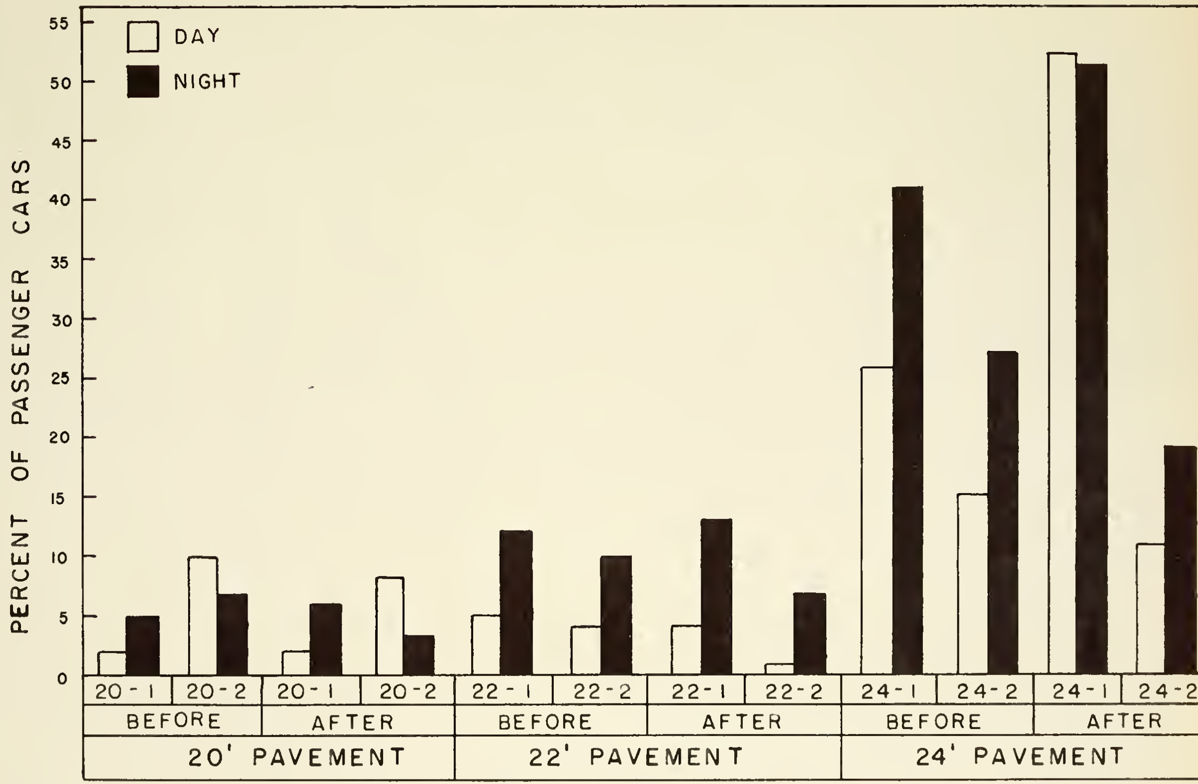
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F(obs)	Signif.
Pavement Width	2	2.29846	1.14923	5.161	NS
Locations in Pavement Width	3	.66804	.22268	--	--
Edge Lines	1	.00004	.00004	1	NS
Pavement Width by Edge Lines	2	.03901	.01951	1	NS
Locations by Edge Lines in Pavement Width	3	.16697	.05566	7.168	*
Period	1	.18624	.18624	6.625	NS
Pavement Width by Period	2	.07074	.03537	1.258	NS
Period by Locations in Pavement Width	3	.08434	.02811	3.621	NS
Edge Lines by Period	1	.00226	.00226	1	NS
Residual	5	.03882	.00777	--	--

Notes - - -

* Rejection Of The Hypothesis That There Are No Population Differences At The 5% Level Of Significance.

** Rejection Of The Hypothesis That There Are No Population Differences At The 1% Level Of Significance.

NS Failure To Reject The Hypothesis Of No Population Difference.



PERCENT OF PASSENGER CARS MORE THAN FIVE FEET FROM PAVEMENT EDGE - SR 43 & US 24

FIGURE 31

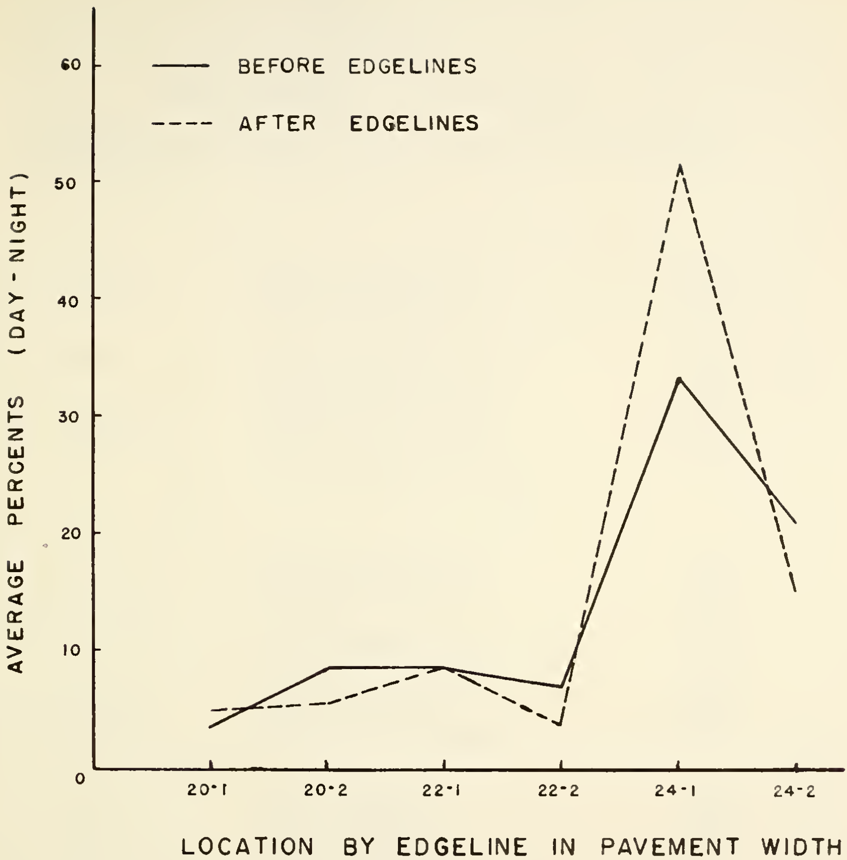

BEFORE EDGELINES
AFTER EDGELINES
AVERAGE PERCENTS (DAY - NIGHT)
60
50
40
30
20
10
0
20-1
20-2
22-1
22-2
24-1
24-2
LOCATION BY EDGELINE IN PAVEMENT WIDTH

FIGURE 32

Table 39

AVERAGE PERCENTS - SR 43 AND US 24

PASSENGER CARS MORE THAN FIVE FEET FROM THE PAVEMENT EDGE

20' Pavement	Before Edge Lines	6.00
	After Edge Lines	5.25
22' Pavement	Before Edge Lines	7.75
	After Edge Lines	6.25
24' Pavement	Before Edge Lines	27.25
	After Edge Lines	33.25
20' Pavement	Day Observations	5.50
	Night Observations	5.75
22' Pavement	Day Observations	3.50
	Night Observations	10.50
24' Pavement	Day Observations	26.00
	Night Observations	34.50
	20' Pavement	5.63
	22' Pavement	7.00
	24' Pavement	30.25
	Before Edge Lines	13.67
	After Edge Lines	14.92
	Day Observations	11.67
	Night Observations	16.92

on the 24' pavement under all circumstances. On a 12' lane, a passenger car can travel more than five feet from the pavement edge, and, because of its lateral dimensions, still be traveling in a safe manner and not encroaching on the opposing lane. This is not the case on the 20' or 22' pavements. It might appear at first that the percents on the 24' pavement in this zone are significantly different. However, it must be remembered, that in transforming these percents to arc-sine values to restore the homogeneity, the variation, naturally becomes much smaller and more uniform, but the ratios between values remain the same.

An investigation was not made of semi-trailer trucks in specific zones of the pavement in this portion of the study because the data were based on a different number of observations for each period. Fifty observations were made during the day and forty observations at night. Consequently, the transformation of percents to arc-sine values to restore homogeneity could not be performed. This fact is brought out in the following statement of the theory on which this type of analysis is based. "When the observations in an analysis of variance are proportions and if all the proportions are based on the same number of observations, and if each is transformed to an angle, homogeneity of variance is secured because each has the same variance, 1/N, even though the proportions differ. (14)."

CONCLUSIONS

EFFECT OF PAVEMENT TYPE ON LATERAL PLACEMENT

The following conclusions are based on the results of the statistical analysis of the data obtained for this study on two types of pavement, portland cement concrete and bituminous concrete:

1. The mean lateral placement of passenger cars is not significantly different on the two types of pavement. However, the overall mean lateral placement is slightly higher on the portland cement concrete than on the bituminous concrete.
2. The mean lateral placement of passenger cars is not significantly different between periods of observation.
3. The mean lateral placement of semi-trailer trucks is not significantly different on the two types of pavement.
4. The mean lateral placement of semi-trailer trucks is significantly different between periods of observation. On both types of pavement, these vehicles are driven farther from the edge at night than during the day.
5. The variance of the lateral placements of passenger cars is significantly different on the two types of pavement. The vari-

ability of the lateral position of these vehicles is significantly greater on the bituminous concrete than on the portland cement concrete. This same variability is not significantly different from day to night.

6. The variance in the lateral placements of semi-trailer trucks is not significantly different for the two types of pavement, nor for the two periods of observation.

7. The percent of passenger cars traveling in the outer three feet of pavement is not significantly different on the two types of pavement, nor between periods of observation.

8. The percent of passenger cars traveling more than five feet from the pavement edge is not significantly different for the two types of pavement, nor for the two periods of observation, day and night.

9. The percent of semi-trailer trucks traveling in the outer two feet of pavement is not significantly different for the two types of pavement,

nor for the periods of observation, day and night.

10. The percent of semi-trailer trucks traveling more than four feet from the pavement edge is not significantly different for the two types of pavement, nor between the two periods of observation.

EFFECT OF PAVEMENT EDGE LINES ON LATERAL PLACEMENT

The following conclusions are based on the results of the statistical analysis of the data obtained for this study on three widths of pavement; 20', 22' and 24'.

1. The presence of edge lines on the pavement has no significant effect on the mean lateral placement of passenger cars on the 20', 22' or 24' pavement. Also, there is no significant difference in mean lateral placement of passenger cars between periods of observation, day and night, on any of the pavement widths.

2. The mean lateral placement of passenger cars on the 22' pavement is approximately 4" farther from the edge than on the 20' pavement, both before and after edge lines, during the day

and at night. Similarly, the mean lateral placement of passenger cars on the 24' pavement is approximately 10" farther from the edge than on the 20' pavement under all conditions.

3. The mean lateral placement of semi-trailer trucks is not significantly different on the 24' pavement after the placement of edge lines. Also, there is no significant difference between these mean lateral placements from day to night.

4. Variance of lateral placements of passenger cars is not significantly different after edge lining on these pavement widths. However, slight decreases in both day and night variances were found after the edge lines were placed. There is no significant difference in this variability between periods of observation.

5. The variability of the lateral placements of semi-trailer trucks is not significantly different after placing the edge lines on the 24' pavement. Again, slight decreases in both day

and night variances were found after the edge lines were placed. There is no significant difference in this variability between periods of observation.

6. The percent of passenger cars traveling in the outer two feet of pavement is not significantly different after edge lining on the three pavement widths, nor between periods of observation.

7. The percent of passenger cars traveling more than five feet from the pavement edge is not significantly effected by the presence of edge lines on the three pavement widths, nor is it significantly different between periods of observation.

Further research should be carried out on the edge lines portion of the study. Another after study should be made in from six months to a year to determine whether or not a gradual rather than an instantaneous transition takes place in driver behavior with the presence of edge lines.

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